INTRODUCTORY PHYSIOLOGY AND HYGIENE

KNIGHT

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INTRODUCTORY

PHYSIOLOGY AND HYGIENE

A SERIES OF LESSONS IN FOUR PARTS

DESIGNED FOR USE IN THE

FIRST FOUR FORMS OF THE PUBLIC SCHOOLS

PARTS I AND II CONTAIN RULES OF HYGIENE FOR PUPILS IN FORMS I AND II, AND NOTES AND QUESTIONS FOR TEACHERS.

PARTS III AND IV CONTAIN RULES OF HYGIENE AND ELEMENTARY PHYSIOLOGY FOR PUPILS IN FORMS III AND IV.

BY

A. P. KNIGHT, M.A., M.D.

PROFESSOR OF PHYSIOLOGY

Queen's University, Kingston.

TORONTO

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Hygiene
Physiology

PREFACE.

A word of explanation is perhaps necessary as to how these lessons came into existence.

In August, 1904, the Education Department expressed to Mr. E. J. B. Pense, M.P.P. for Kingston, a desire to improve the model schools of the province. The communication was transmitted to Dr. Dyde, then Chairman of the Kingston Board of Education, and, as a result, arrangements were made that three short courses of lectures (one of which was in physiology and hygiene) should be given to the teachers-in-training in the Kingston model school during the autumn. After three or four demonstrations had been given, it became apparent that, if the instruction was to be made effective, some model lessons would have to be taught to school children in presence of the teachers-in-training, and so it came about that ten lectures, or most of what is included in Part IV of the book, were given in the University Buildings to the students of the model school, and most of the lessons in Parts I, II and III were taught to pupils in the first four forms of the Kingston public schools. In nearly every case the lessons are published in the form in which they were prepared and taught. A few have been added in order to complete the new curriculum. They varied in length from ten minutes in Form I to twenty minutes in Form IV.

Footnotes were inserted while the book was passing through the press. This was done on the ground that few schools possess books of reference, and that the teachers should therefore be supplied with the information necessary for teaching the lessons.

The course was given without remuneration of any kind and solely with the view of helping to improve the training given in the model school, and the book may be considered as a detailed report upon the work done during the session with the teachers-in-training.

Most of the illustrations are from photographs taken by Cyril Workman Knight, B.Sc., London Exhibition Scholar, in Columbia University, New York.

The three illustrations of the treatment of the apparently drowned have been specially prepared for this book, and show the latest positions recommended in this method of resuscitation.

In preparing the lessons for publication, valuable suggestions and criticism were received from John Dearness, M.A., Vice-Principal of the London Normal School, and from R. H. Cowley, M.A., Inspector of schools for the county of Carleton.

I am greatly indebted to Dean Connell, Professor James Third, M.B. (Tor.), Professor Isaac Wood, M.A., M.D., and Professor W. T. Connell, all of Queen's University, and to A. E. Attwood, M.A., Ottawa, for kindness in reading the proofsheets and in making suggestions for improving the book.

INTRODUCTION.

It is hoped that no teacher will attempt to teach physiology to children without demonstrations and experiments. Physiology is a part of nature-study, and as such can furnish its highest educational value only when children come into direct contact with nature. This book assumes that the subject will be taught in this way, and if so taught, the knowledge acquired cannot fail to contribute to the preservation of health and to that pleasure in life which is so largely dependent upon good health.

A little consideration will show that the only instruction that can be given to pupils in Forms I and II of our public schools, under the head of physiology and hygiene, must be limited to hygiene. The rules of health as stated by the best authorities in medical science must be taught at first dogmatically to young children. The reasons for the rules cannot be understood by pupils in Forms I and II because the rules for preserving health are based upon a full knowledge of physiology, and a full knowledge of physiology implies a wide knowledge of physics and chemistry, and, along with this, a somewhat comprehensive knowledge of anatomy. To realize the impossibility of teaching hygiene in any other way, it is only necessary to glance at the curriculum of any regular medical school. Such a school requires its students to spend

two years on anatomy and physiology, and only after this, are hygiene and sanitary science studied. These latter are "final subjects" in a medical course.

The difficulty in teaching physiology and hygiene to young pupils is great enough; but, when a teacher is required in addition to teach the ill-effects of stimulants and narcotics upon the various organs of the body, he is confronted with the difficulty of teaching to school children another "final" subject of the medical curriculum —pathology. Every rational parent and teacher recognizes the terrible and degrading effects of indulgence in alcohol, opium and such like drugs, and the necessity of impressing upon children the dread of becoming slaves to their use; but surely this end can be attained without attempting to teach the changes which are produced in the tissues by these drugs—changes which experts themselves find it difficult if not impossible to understand.

Manifestly, then, in teaching hygiene to young children we must just accept the best teaching of medical science as regards the care of mind and body, express this teaching in a set of simple rules, and require young pupils to learn them. In doing this we can only hope that children who do not continue in school beyond Form III may nevertheless be induced to practise these rules of health after leaving school, just as we hope that they may practise the ordinary rules of conduct and morals.

With pupils in Form IV and perhaps in Form III the case is different. Here some further knowledge of anatomy and physiology may be acquired by observations

of parts of animals such as can be obtained in either a kitchen or a butcher's shop. With a little trouble on the part of teachers the subject can be made both interesting and instructive. This little book has been published with a view of inducing teachers and pupils to adopt this method of study. Most school text-books have in the past treated the subject in a purely descriptive way. They have, moreover, given too much space to descriptions of the bones, joints, etc., and too little to the nervous system which controls and regulates every function of the body. In the following pages the functions of the nervous system have been made prominent, because the author wishes to make pupils understand clearly that the great activities of the body—muscular movement, digestion, respiration, circulation of the blood, animal heat and excretion—are all under the control of the nervous system, and are made by the nervous system to work in harmony with each other in the interests of the body as a whole.

The order and the scope of the lessons follow pretty closely the course of study in physiology and hygiene that has recently been prescribed for the first four forms of the public schools. The method of treatment is the well-known laboratory method in which demonstration is made the basis of observation by the pupil, and, of course, the conclusions which he is expected to form. This method needs no defence in the teaching of physiology, for it has stood the test of twenty years' trial in physics and chemistry in the high schools of Ontario, and it is, moreover, the method urgently pressed upon the attention of teachers in the new programme of nature-study for public schools.

There is one part of school hygiene that demands the special attention of teachers who have the interests of their schools at heart, namely, the practical examination of pupils in order to discover defects in sight or hearing.

Many things about school life tend to injure the eyesight of children. The lighting in many schoolrooms is very bad; the size of type and paper in textbooks is objectionable; blackboard work is often dim and small; and the writing upon greasy slates is illegible. Add to these predisposing causes of poor eyesight the fact that glossy copy-books are often a source of strain; that too much writing is imposed upon pupils; that wall maps and book maps have frequently very small type; that in the case of girls, there is fine needlework to be done at home—often at night, and with very imperfect sources of light, and it will soon be seen that we have in schools nearly all the conditions possible for impairing the eyesight of many of our children.

Dr. Cohn, of Breslau, in 1873, examined the eyes of more than 10,000 school children, and found the percentage of shortsightedness increasing from year to year as follows:—

Elementary School	6·7	per cent.
Intermediate School	10·3	"
High School	19·7	"
Gymnasia	26·2	"

Shortsightedness is a prevalent defect among school children. Whether it is on the increase or not in Canada no one can say, because no systematic examination of the eyesight of children has been made, and consequently no data are available upon which to found an opinion; but, whether it is on the increase or not, one thing is

certain, teachers cannot work intelligently in school if even as small as six per cent. of the pupils have defective sight or hearing. Some recent statistics seem to indicate that 20 per cent. of school children suffer from defective hearing. In one class in a Kingston school no fewer than 70 per cent. were found to have suffered from earache.

Every teacher, therefore, should test the eyesight and hearing of his pupils at least once a year, preferably at the re-opening of the schools after the summer vacation. The results of the examination should be recorded in a small book, and parents should be warned if defects are serious, or appear to be growing worse.

There is no difficulty in conducting such an examination. At the end of this volume will be found a folded sheet of paper with four sizes of type printed upon it. These have been taken from Snellen's test letters. Below each line of these letters is printed the distance in feet at which pupils with normal eyesight are able to recognize them. The sheet should be cut out and pasted smoothly upon a large piece of cardboard. This should then be hung up where a good light falls full upon it, and where it is on a level with the eyes of the pupil whose eyesight is to be tested. The teacher should measure off 20 feet on the floor from where the card is hung, and then test the ability of the pupil to recognize readily the largest letters at this distance. The next size should then be used, and so on down to the smallest. The right eye is to be tested first, a piece of cardboard being placed before the left eye in order to obstruct its vision. Pupils who can read the smallest

letters on the card at 20 feet have normal vision. After their names in the register should appear the record R.V. $\frac{20}{20}$. The letters and figures R.V. $\frac{20}{20}$ mean that vision in the right eye is normal. The left eye should be tested in the same manner, and if found normal, a corresponding record, L.V. $\frac{20}{20}$, should be entered.

If only the size next to the smallest can be read by the pupil at 20 feet, the record should be R.V. $\frac{20}{30}$, L.V. $\frac{20}{30}$, and so on for the other rows of larger letters. If a pupil can at 20 feet read only the largest letters R. & L.V. $\frac{20}{60}$, he is shortsighted, and the defect should be at once reported to the parent with the request that the pupil be taken to a physician for examination and treatment.

The sense of hearing can easily be tested by the ticking of an ordinary watch. The two ends of a tape measure should be suspended at such a height from the floor as will place it on a level with the ears of the pupil whose hearing is to be tested. One ear should be covered with a pad of cotton and bandaged so thoroughly that no ordinary sound can be heard by that ear. The pupil should then be made to stand with his back to the teacher and his eyes closed. For convenience in reading off the distances, the pupil should be placed at the end of the tape measure marked one inch. The teacher should then hold a watch in his hand and on a level with the child's ear, but not touching the tape. The watch should at first be placed so far away that it cannot be heard by the pupil. The teacher should then slowly approach the pupil, and the latter should signify when he hears and when he does not hear the ticking of the instrument. The watch should be

moved towards and away from the pupil a number of times, so as to make sure of the distance at which the pupil hears it. This distance is then read off on the tape measure, and entered in a record book.

Of course the relative loudness in the ticking of a watch, as well as the noises in the immediate neighborhood of a school, must be taken into account, if comparisons are desired with pupils elsewhere, or with the records of the same pupils in different years. But for the mere purpose of detecting defects in hearing, the method described is quite sufficient. From two and a half to three feet may be taken as the far limit at which the ticking of an ordinary watch may be heard. Deviations from the normal can readily be determined by averaging the various tests of a class of say, forty pupils. Pupils with defective hearing should of course be seated near the teacher.

It only remains to say that every teacher in charge of a class in physiology and hygiene should have at hand reliable works of reference in anatomy and physiology. Moore's Elementary Physiology, Halliburton's Handbook of Physiology, Foster's Physiology, Stirling's Practical Physiology, Dorland's Medical Dictionary, Bergey's Principles of Hygiene, and Shaw's School Hygiene should be in every school library.

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PART I.

LESSON I.

The Parts of the Body.

The youngest pupils in a school are likely to know the chief parts of the human body, but a careful teacher takes nothing for granted. Accordingly, pupils should be asked to enumerate the parts of the body, and these should be written upon the blackboard in some regular order. The following is suggested :—

1. The head.
2. The neck.
3. The trunk.
4. The upper limbs, or arms.
5. The lower limbs, or legs.

Then should follow the enumeration of the subdivisions of these parts. These should be obtained as far as possible from the class and written upon the blackboard.

Head : face, back, crown, sides, hair, ears.

Face : forehead, eyebrows, eyelids, eyes, nose, mouth, cheeks, lower jaw, chin.

Arm : upper arm, elbow, forearm, wrist, hand.

Hand ; back, palm, fingers, tips, thumb, ball, joints, nails.

Trunk: the upper parts of the trunk are the breast, back, spine, shoulders, sides (the word "chest" would include all of these parts except the shoulders). The lower parts are waist, abdomen, back, sides, hips.

Legs: thigh, knee, lower leg (its front part the shin, its back part the calf), ankle, foot.

Foot: instep, arch, sole, ball, heel, joints, toes, nails.

LESSON II.

THE HAIR.

Materials: a hair from a pupil's head; hairs from a pig; sheep's wool.

The teacher may begin by asking such questions as: Does any hair grow on the back of the hand? Upon the legs? What domesticated animals have hair growing upon their bodies? On what part of a cat's body is there no hair growing?[1] What is the use of wool to the sheep? How does wool differ from hair? From pigs' bristles?[2]

Making each pupil look at a single hair, ask the class how to distinguish the **root** from the **shaft**. The root is

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[1] On the tip of its nose and soles of its feet.

[2] It is finer and longer. Bristles are much coarser than hair; nor do they grow so thickly on the body.

The hair of furred animals is fine, short and thick. On cattle the hair is longer and coarser.

Teachers should express the rules of hygiene in the simplest language so that the youngest child may understand what is meant.

the end with the small knob on it. It lies below the surface of the skin and has a small gland attached to it which secretes the oil that gives the natural gloss to the hair. The shaft is the rest of the hair. The shaft of the hair on the head keeps growing out from the root as long as the hair lives. Dust from the air and dirt from other sources cling to the natural oil of the hair and this renders it necessary to wash the hair.

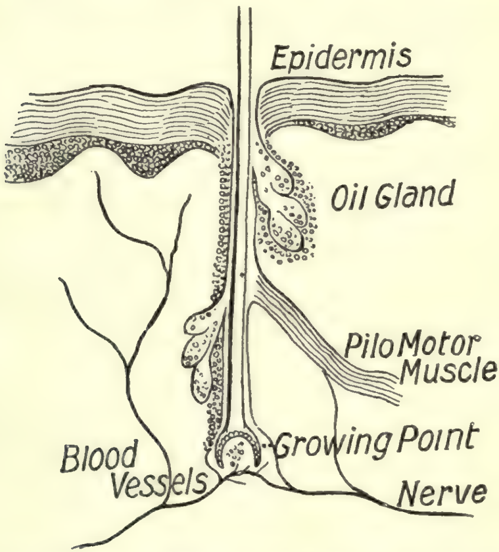

Fig. 1.—Diagrammatic vertical section of skin showing hair follicle.

Care of the Hair.

1. The hair and scalp of children should be washed at least once a week with castile soap and lukewarm water.

2. The best time to wash the hair is just before going to bed and it should be thoroughly dried.

3. The hair should be combed and brushed three times a day.

4. No oil or grease should be used on the hair.

LESSON III.

The Teeth.

Materials: human teeth obtained from a dentist; jaw of an ox sawn open to show the root in the jawbone.

The teacher should ask such questions as will enable the pupils to recognize the difference between the visible part of a tooth, the **crown,** and the part that is embedded in the jaw, the **root.** The junction of these two parts is the **neck.** This lies at about the edge of the gum.

Pupils should be asked, also, whether there is any difference between the surface or **enamel** which covers the crown of the tooth and the surface of the root.[1] By further questions they may be led to classify teeth into the cutting teeth or **incisors,** the chewing teeth or **molars,** and the pointed teeth or **cuspids.** Differences in the size, shape and position of these in the jaw can

[1] The bulk of a tooth consists of *dentine.* Enamel, a very hard, calcareous matter, covers the dentine composing the crown; a *cement* or *crusta petrosa* covers the dentine of the root. Dentine is a kind of ivory; the cement-covering is true bone.

readily be recognized by directing pupils to study their own teeth with the aid of a hand-mirror.[1]

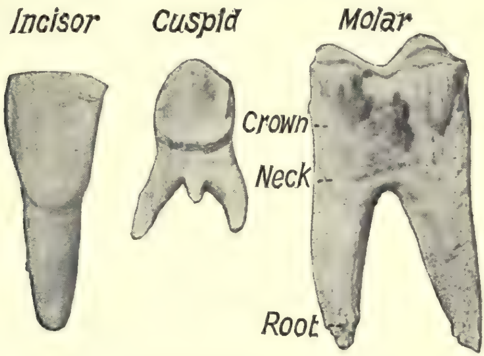

Fig. 2.—Three teeth from the jaw of an ox.

CARE OF THE TEETH.

1. Brush the teeth after each meal, using a brush with soft bristles.

2. In brushing them use castile soap. If toothpowder is used, it should be free from any hard, gritty substance such as would wear off the enamel.

3. Very cold food or drink taken into the mouth immediately after hot food or drink is likely to crack the enamel and start decay of the teeth.

4. Cracking nuts with the teeth, or biting any hard object is also likely to crack the enamel.

[1] A full set of temporary teeth in children consists of eight incisors, four canine, and eight molars.

LESSON IV.

The Skin.

Materials: solution of salt in water; some of it to be allowed to evaporate upon any dark substance. The white spot thus produced will illustrate the residue left by sweat after drying on the skin.

The lesson may be begun by eliciting the experience of those pupils who have cut or pricked the outer surface of the skin and yet felt no pain and drawn no blood. Against this will be the general experience of the class that blood flows and pain is felt whenever the skin is cut. In this way the class can soon be made to see that one use of the skin is to cover and protect certain things which lie beneath. The pupils may then be told that these underlying structures are **flesh,** including **blood vessels** and **nerves.**

Attention may be called to another function of the skin by asking where sweat comes from. This question cannot be answered, of course, by young pupils, but it will give an opportunity to the teacher to explain that the sweat comes out to the surface of the skin through many very small holes or pores which occur all over the body.[1] Dust from air and from other sources adheres to the moistened skin which thus gets dirty where it is exposed. But even where the skin is covered by the clothing the sweat, in drying up, leaves behind it a little

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[1] It has been estimated that there are about 2,500 sweat pores on every square inch of skin. There are from eighteen to twenty square feet of surface of skin on the body of a man of average size.

The skin consists of two layers: an outer one that possesses no sensibility and an inner one that does.

solid material. This dirt, if not washed off, accumulates, clogs up the sweat pores, produces an unpleasant odor and tends to impair the general health. Hence arises the necessity for not merely washing the clothing regularly, but also bathing the body.

Care of the Skin.

1. A robust person should take a cold bath, or at least a sponge bath, every morning. The skin should then be rubbed vigorously with a coarse towel until dry, and until the person feels a warm glow.

2. Children who are not vigorous should take a lukewarm bath before going to bed. But even they should accustom themselves gradually to a cold sponge, or shower bath.

3. All soap should be rinsed from the skin in clean water before drying.

4. Systematic bathing in cold water is a protection against taking cold.

LESSON V.

The Nails.

What evidence is there that nails grow?[1] What do nails in human beings correspond to in the cat or dog? What is the use of fingernails to man? How do we pick up very small objects? Are there any nerves in

[1] They have to be cut. Nails protect the ends of the fingers, add to their beauty, and are useful in picking up small objects. There are no nerves and no blood vessels in nails.

the nail? Any blood vessels? Are there any blood vessels underneath the nail? To answer this question, press the end of the nail of one finger firmly against the surface of the nail of another finger. The pressure drives the blood temporarily out of the underlying blood vessels, and a white spot is produced.

Nails are a thickened growth of one of the layers of the epidermis of the skin. The part from which growth takes place towards the end of the finger is the **root.** Nails sometimes come off, but will grow again if the root has not been destroyed.

Care of the Nails.

1. The nails should be kept clean by the use of a nail brush and nail cleaner.

2. A sharp penknife should not be used for removing dirt from beneath the nails, because the sharp blade scrapes off the natural lining of the nail and renders future attempts to clean the nail more difficult.

3. Sharp scissors—not a penknife—should be used in cutting the fingernails. They should then be filed smooth.

4. Biting the fingernails is a disagreeable habit, and tends to spoil the shape of the ends of the fingers.

5. Ingrowing nails may often be relieved by cutting a **V**-shaped piece out of the end of the nail. This relieves the downward pressure at the sides and stops the ingrowing.

6. Disease germs are always present under the fingernails. Picking or scratching pimples with the nails

should be avoided, because the practice is a disagreeable one in itself, and may lead to the transfer of disease germs from the nails to a pimple, thus causing a boil or abscess.

LESSON VI.

THE EYE.

The external parts of the eye should first be taught. This can easily be done by standing one pupil in front of the class and pointing out on his eye its principal parts. The eyebrows, upper lid, lower lid, eyelashes, white of the eye, iris or colored part, and the pupil, or dark circular opening in the iris, should all be pointed out. The position of the **tear gland** should be indicated, and also the path of the **duct** which conveys the tears to the upper part of the nose cavity.

There might then follow some questions upon the use of these various parts. When perspiration is running down the forehead in drops, do the eyebrows shed the drops from the eyes?[1] What is the use of winking or "blinking"? Why is the eye placed in a hollow, surrounded by bone?[2] In what other way is the eye protected besides by projecting bone?

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[1] The eyebrows shed the perspiration off the forehead ; the eyelashes shed it from the lids. Both assist the eyelids and pupil in protecting the eye and in regulating the amount of light entering the eye.

[2] The eye is protected by the bony orbit and by the eyelids. The front of it is washed by tears that are spread over it by winking.

Care of the Eyes.

1. Particles of dust, larger than can be removed by the tears, can often be removed by lifting the upper eyelid with the finger and thumb and drawing it down over the under lid.

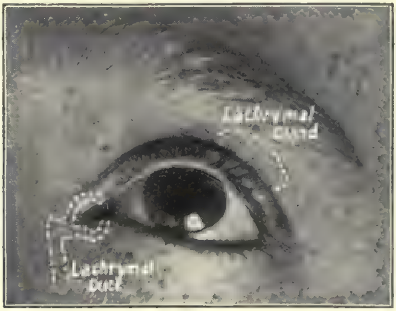

Fig 3.—Human eye, showing the position of the tear gland and of the lachrymal duct, down which the tears pass to the nasal cavity.

2. If this does not remove the particle, do not rub the eye. A soft silk handkerchief folded or rolled into a point may be passed gently over the eyeball and the particle thus brushed off.

3. If this does not suffice to remove it, a doctor should be consulted.

4. If a child has difficulty in seeing objects clearly, his eyes should be examined by a physician.

5. The best artificial light for night work is diffused white light.

6. Headaches are sometimes caused by defective eyesight. If headaches are frequent, the eyes should be examined by a physician.

LESSON VII.

The Outer Ear.

The ear consists of three parts, the outer ear, middle ear, and inner ear. Only the visible parts of the outer ear should be taught to young pupils. These parts are the **pinna, concha** and **meatus.** The meatus, called also the canal, is the opening leading into the head, and is closed at its inner end by the **drum.** The drum resembles somewhat a thin piece of skin stretched across the end of the meatus (see Fig. 10).

The parts of the external ear can be taught by pointing them out to the class on the ear of one of the pupils. They should then be asked to name some animals that have small, erect "ears," and others which have large, hanging ones. This they will readily do; but they will likely be unable to recognize these parts in frogs, toads, or birds. In fact, pupils will be puzzled to recognize the location of ears anywhere on the head of these animals.[1]

Care of the Ears.

1. The ears should be kept clean by washing as far as the outer opening of the tube leading into the drum.

2. Small, round objects like peas should never be put into the ears.

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[1] Frogs and toads have no external ear. In most birds the location of the meatus is marked by a few feathers that are more prominent than the surrounding ones. The opening generally lies a little back of and below the eye.

3. The pinna should not be pulled; nor should the ear be "boxed." Children should not be punished by being struck on any part of the head.

Fig. 4.—External ear. The concha is the central hollow surrounded by the double prominent rims which constitute the pinna. 1 is the outer of these two rims.

4. A cold in the throat sometimes causes earache by the inflammation extending up into the middle ear. The pain can sometimes be relieved by applying a hot water-bag or hot flannel cloths to the ear and to the side of the neck. Repeated colds sometimes cause deafness.

LESSON VIII.

Eating.

"Eating is the act of taking food." How then do we take food when it is placed before us on the table? A little questioning will draw out the different methods employed by well-bred people. Some kinds of food are taken with the fingers; some with forks; some with spoons. Pupils should be asked to give examples of

foods taken in these three ways. The teacher should here seize the opportunity of teaching a little of the etiquette of the table. What is the proper use of the knife? Attention should be called to common objectionable methods of taking food, such as smacking the lips, blowing hot tea in a saucer, and such other practices as are offensive to good taste.

After "taking food" into the mouth what is done with it? Why is it chewed?[1] What is mixed with it as it is chewed? Between what teeth is it chewed—front or back? Why the back teeth—molars? Is there any objection to swallowing the food as soon as it is taken into the mouth, as a dog does?

Rules for Eating.

1. Chew all solid food thoroughly so that it will be ground into small pieces and mixed with the juices of the mouth before it is swallowed.

2. Take about half an hour to a meal. Do not bolt your food.

3. No work of any kind, especially manual labor, should be begun until about half an hour after a meal has been finished.

4. For children, fluid and simple foods are best, because they are most easily digested.

5. Alcohol is not a food. It should not therefore be taken as either a food or a drink.

[1] Food is chewed in order to reduce it to small pieces, so that the juices of the mouth, stomach and small intestines may come into contact with every part of it. It is the first step in the process of digestion. Bolting the food entails more of the labor of digestion upon the stomach and intestines than they ought to bear. Dogs in bolting their food simply follow the habit of their wild ancestors.

LESSON IX.

Drinking.

If asked to enumerate the liquids which people are in the habit of drinking, either alone or along with solid food, children will likely mention water, milk, tea, coffee, cocoa, chocolate, ale, beer, porter, wines, brandy and whiskey. Asked why we drink, they will probably answer that it is because we are thirsty. If we push the inquiry a step further and ask how it is that we become thirsty we shall likely get no answer. They may then be asked if any water leaves the lungs, and if any leaves the skin. Breathing on a piece of cold glass will show the loss of water by the lungs, and drops of sweat are a sufficient indication that water is lost by the skin. It will, of course, occur to most of them that water is also withdrawn from the body by the kidneys. If now we go back to our question: Why do we become thirsty? pupils will probably see that the loss of water by the lungs and skin and kidneys must be supplied by our drinking water or some other liquid.

Where is the sense of thirst felt most keenly? In the mouth and throat, of course, but the fact is, that it is the blood which has lost water through the lungs, skin and kidneys, and it is the blood which demands water when we feel thirsty.

How shall we best satisfy our thirst? This question will elicit various answers. Water and milk will meet with most favor; but tea, coffee, cocoa and chocolate will all have their supporters, and some ill-advised pupils will even defend the drinking of ale and wine, if not of whiskey.

Rules for Drinking.

1. Pure water is the best drink of all.

2. Milk, cocoa and chocolate are foods as well as drinks. Consequently we should eat less solid food if we drink these liquids at any meal.

3. Tea and coffee will also satisfy thirst; but, if indulged in immoderately, in time they injure the nerves and upset the digestion of every one except the very strongest and most healthy.

4. Ale, beer, porter, wine, brandy and whiskey will satisfy thirst temporarily; but their use is dangerous, because they create an appetite for more that may become uncontrollable.

LESSON X.

Breathing.

Materials: tape measure; watch.

How often do we breathe in a minute?[1] This may be left to the pupils themselves to determine. Three of them can work together in counting the respirations; one holding a watch and noting the time, one counting, and the third acting as "patient." It will generally be found that the "patient" breathes more slowly than is natural when he is under observation.

Children may also be assigned the problem of ascertaining at home whether adults breathe faster or slower than children.

[1] The number of respirations in a healthy adult ranges from fourteen to eighteen per minute. It is greater in infancy and childhood, and increases a little again in old age.

Another useful determination which children can make is that of chest measurement during forced inspiration and again during forced expiration. This is done by means of a tape measure, and will direct special attention to one of the rules for breathing.

Rules for Breathing.

1. We should always breathe through the nose, whether sleeping or waking; whether at rest, at work or at play.

2. If a person finds difficulty in breathing through the nose, he should at once consult a physician.

3. After going into the fresh air, we should always take a few long breaths so as to thoroughly expand the lung-chambers and change all the air in them.

4. Boys should not smoke cigarettes, because this habit will stunt their growth.

LESSON XI.

Sleep.

The teacher can introduce a lesson on sleep by asking different pupils when they go to bed each evening and when they rise in the morning. They may also be asked whether household pets, such as cats, dogs, or rabbits, take any sleep.[1] Do birds sleep? Do horses and cows sleep, or do they simply rest at night without sleeping? Why do people need sleep? What may prevent people from sleeping as well in the daytime as at night?

[1] Of course we cannot be absolutely certain as to the sleeping habits of wild animals; but all our domesticated animals sleep. In the case of wild animals, some sleep at night and hunt for food during the day; others reverse these times.

What occupations require men and women to work regularly at night?

Rules about Sleeping.

1. We should go to bed as nearly as possible at some regular hour, and rise at some regular hour.

2. We should sleep on a moderately hard but clean bed, with a low pillow.

3. It is better to sleep on either the right or the left side rather than on the back. We should sleep chiefly on the right side.

4. Young school children should sleep about ten or eleven hours; older pupils, nine to ten hours. Adults should sleep about seven or eight hours.[1]

LESSON XII.

Bone.

Materials: a long bone—for example, a rib—from any old animal, and the corresponding bone from a newly-born animal.

The first point to make clear to children in the study of bone is that the bones in all young animals are comparatively soft and easily bent, whereas the bones in old animals are hard and brittle. This can be brought

[1] Periods of sleep and exertion alternate as a law of life. Night is the time when it is natural for people to sleep. Noises due to the activity of our daily occupations will naturally interfere with the sleep of those who are forced to work at night and sleep during the day. Some factories—for example, glass factories—must be worked night and day, and consequently employees in these must take their turn at night work.

out best by comparing a bone from a young animal with a bone from an old animal, and noticing differences in size, weight and flexibility. But the lesson may be impressed nearly as well by trying to bend or break the breast bone in an old fowl that has been prepared for market, and then comparing this with the breast bone of a chicken also prepared for market. The leg bone from a newly-hatched chicken will also bring out this same difference.

The class may then be told that our bones in infancy and childhood are soft and easily bent ; but that they gradually become firmer and harder as we grow older.

Care of Bones.

1. An infant should not be allowed to stand or walk until his leg bones are strong enough to bear the weight of his body. When an infant is encouraged to walk too soon he sometimes becomes bow-legged.

2. Children should aim at walking and sitting erect, and with the shoulders well thrown back. If they acquire this habit they will usually have a large chest-capacity for breathing.

3. No waists, belts, vests or corsets that will tend to lessen the size of the chest or waist should be worn by children, because the pressure which tight clothing exerts will destroy the shape of the chest bones and lower ribs, and lessen the space for breathing and food.

LESSON XIII.

Tendons.

Materials: a fowl's leg and foot; ligaments from around any joint.

What is meant by a tendon may be clearly brought out by calling attention to the "cords" or tendons at the wrist. Make the hand move forward and backward and watch the tightening and slackening of the tendons. Now, take the fowl's leg and lay bare the tendons at the point where the leg is usually cut off when preparing the fowl for the table. Then remove the skin up the leg, and follow one of the tendons up the leg until it enlarges and joins the lean meat or **muscle.** This is the main point in the demonstration. Muscles, or the subdivisions of lean meat, have generally, at one or both ends, white, strong bands or cords, called tendons. Show the pupils that, by pulling on the muscle, the cord pulls on the bones of the foot and makes them move as the animal does during life. Our muscles move when we send a message to them along a nerve from the brain (see Fig. 5.) From the part of the brain marked "motion" messages are sent out to muscles in contraction. When the message arrives at the muscle, the muscle pulls on the tendon and causes movement.

Ligaments are the very tough and strong bands or sheets which bind bones together at joints. They overlie the bones and along with the muscles keep the bones of a joint in their place and limit the movement. At all movable joints one large ligament surrounds the ends of the two bones and forms a closed sac known as a

capsule. On the inside of the capsule there is a thin lining which makes a fluid that lubricates the joint, just as oil lubricates a piece of machinery.

LESSON XIV.

Sight, Hearing, Taste, Smell.

What four senses are located in the head? What are the organs of these senses[1]? What senses are located in other parts of the body?

What information can we get about an object by using each of these senses[2]? What sense do we use most? What information cannot be obtained by the sense of sight? Supposing a boy to be blindfolded and placed in a strange room, through what sense would he learn something about his surroundings? Show pupils a candy, biscuit, or any other savory article, and ask them to describe it. They will naturally begin by giving its color, shape and size, as these can be judged by the **eye.**

The same objects may then be distributed to the class and they may be asked to describe these objects further,

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[1] The organ of sight is, of course, the eye; of hearing, the ear; of smell, the upper part of the nose cavity; of taste, the tip and sides of the tongue, and also its posterior third. To a slight extent taste is also present in the throat.

[2] All that children know about objects they learn by the use of their senses, including the sense of touch, muscle sense and pressure sense. People who are blind and deaf depend chiefly upon the muscle sense and sense of touch for what they learn of the world around them.

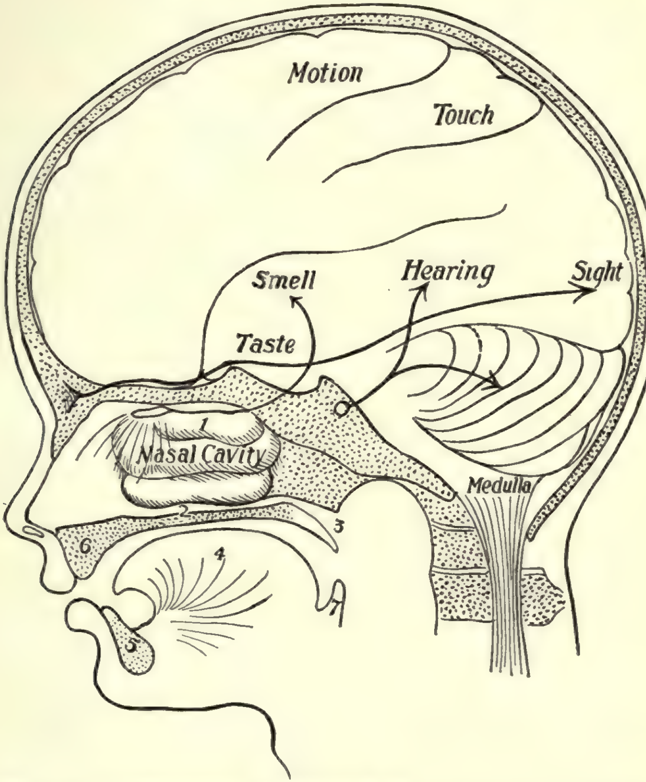

Fig. 5.—Diagrammatic. The heavy lines from the eye, nose and ear represent the nerves along which impulses or messages travel from these organs to the different parts of the brain. Another line might be drawn from the tongue to represent the nerve of taste. The area marked "motion," is the part of the brain which controls the movements of head, face, arms, legs and trunk. It is triangular in shape, and extends well forward towards the forehead, and downwards at the sides towards the area for taste. 1, the upper part of the nasal cavity called the olfactory region; 2, the respiratory region; 3, the posterior nares or opening into the throat from the nose; 4, the tongue; 5, bone of lower jaw; 6, bone of upper jaw; 7, the epiglottis, the small tongue-like covering of the opening into the windpipe.

and to name the sense through which the information comes.

The foregoing considerations will enable pupils to see that we are endowed, not with "five" senses, but with a number. Thus we have the sense of **sight, hearing, smell, taste, touch, heat, cold, pressure, pain, thirst, hunger,** and **muscular sense.** Through one or more of these, information is passing along nerves to the brain during all our waking hours, and we thus learn many things about the world around us. The heavy lines from the eye, nose and ear in Fig. 5 represent the path of messages along nerves from each of these organs to different parts of the brain.

LESSON XV.

Clothing.

We wear clothing in order to be comfortable. In warm weather the clothing is light, and such as will allow the heat of the body to pass away into the air. In cold weather the clothing is heavier, and is intended to prevent the heat from passing away from the body; that is, we aim at keeping as much of the heat as possible within the body. Roughly speaking, then, we need two kinds of clothing, and we make these two kinds out of linen and cotton, on the one hand, and wool and fur, on the other hand. That clothing is warmest which is filled with many little air-spaces, because the imprisoned air in the spaces of the cloth is a poor conductor of heat, and thus prevents the heat from leaving the body. For this reason two light garments,

worn one over the other, are warmer than a single garment of the same weight.

Fat people can do with less clothing than lean people, because the fat that lies under the skin keeps in the heat. More clothing is required when a very strong, cold wind is blowing than when there is a calm, even with a very much lower temperature, because the cold wind penetrates the meshes of the clothing and carries away the heat. In very cold, stormy weather, fur is the warmest clothing that can be worn.

Rules about Clothing.

1. We should never sit or lie down in wet clothes or with wet feet.

2. We need more clothing for our beds than for walking about, because the muscles generate more heat when we are walking or standing than when we are lying down or asleep.

3. The change from winter to spring or summer clothing should be made a very gradual one in order to avoid catching cold. Woollen underclothing should be worn in autumn, winter and spring; and, if people are not vigorous, a lighter kind should be worn in the summer also.

4. Tight clothing should never be worn; it interferes with the digestion of our food, with our breathing, and also with the flow of blood through the body. Tight clothing round the waist is specially bad for the health.

5. If the throat is delicate the neck should be protected with mufflers or other suitable covering when exposed to cold drafts or winds. Low-necked dresses are a fruitful source of disease of the respiratory passages.

PART II.

LESSON I.

The Bodies of Animals.

Having learned the parts of the human body, pupils should be asked to identify corresponding parts in pet animals. They will have little difficulty in doing this in the case of cats and dogs. They will be able also to point out differences between the human body and that

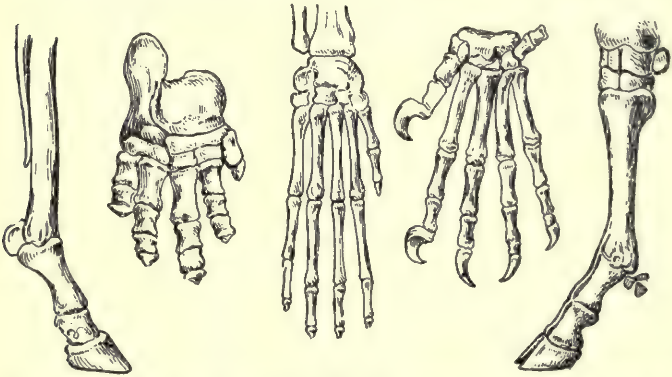

Fig. 6.—Hand, or front foot of various mammals. The first to the left is that of the horse, which walks on one toe (the middle) only; the next, that of the elephant; the next, the ourangoutang; the next, the sloth; and last, the ox.

of these animals; but in the case of cows and horses there will be greater difficulty. It will be found quite beyond the power of school children to identify all the corresponding parts in the common fowl. If told that

cows, sheep, pigs and horses all walk on parts which correspond to our fingers and toes, pupils should be able to identify the remaining parts.[1] Horses walk upon one toe; cows, sheep and pigs upon two toes; but at least two other toes may be seen higher up on their feet. Fig. 6 shows the one toe of the horse; the five toes of the elephant, ourangoutang and sloth; and the two toes of the ox. A short distance above the foot of the ox may be seen two other short toes which do not reach hard ground, but which help to keep the animal from sinking into soft or marshy ground. A similar arrangement of the toes is found in pigs, deer and sheep.

LESSON II.

THE HAIR.

Materials: the same as those required in Part I, Lesson I, and in addition bird's feathers.

Questions, a little more difficult, may be asked in this Form, than in Form I. The following are suggested: What is one use of the hair that grows upon the arms? To elicit an answer to this question ask the class to **touch** these hairs lightly with a pen or pencil.[2] How

[1] In the hind limbs of the common fowl, and in birds generally, the ankle joint occurs between the two rows of the ankle bones. The one row fuses with the tibia, forming with it one bone, the tibio-tarsus; the other row fuses with the second, third and fourth metatarsal bones, and forms one bone, the tarso-metatarse. With this explanation, the brighter pupils may be able to identify the other parts.

[2] When the hair on the back of the hand is touched we feel it; hence these hairs are organs of touch.

do the hairs that grow upon the head differ from those which grow upon the arm as regards color, size, use? Why are there no hairs growing on the soles of a cat's foot?[1] Why is the hair smooth and glossy on some horses, and rough and dry on others? Is this true of other animals besides the horse?[2] Is it true of hair on the human head? Of what use are feathers to a bird? Where on the human head does hair first begin to turn grey?[3] Where does hair first begin to fall off the head? Ask how many pupils can move the scalp forward and backward.

Care of the Hair.

1. Hair should be washed before going to bed and thoroughly dried so as to prevent catching a cold in the head. If done during the day the washing should be finished in cold water and the hair rubbed dry.

2. Hair should be frequently brushed so as to remove dandruff and redden the scalp. Friction improves the circulation of the blood in the scalp and thus tends to prevent the hair from falling out. A stiff brush should

[1] No hairs grow upon the soles of a cat's or a dog's foot, as they would get worn off in walking. So, too, no hairs grow upon the palms of the hands or soles of the feet of a man.

[2] Well-fed animals have healthy hair. It is glossy because the natural oil of the hair in such animals is abundant. Grooming them removes the dead hair, and this also helps to improve their appearance.

[3] On the scalp over the temples. It usually begins to fall off on the crown. The scalp can be moved forwards and backwards by the contraction of a muscle that underlies the skin at the front and back parts of the head.

be used, and the brushing should be brisk but not painful.

3. Hair should not be curled with curling tongs or hard paper. If curled artificially, soft old silk should be used. The continued use of curling tongs injures the hair and helps to make it turn grey and fall out.

4. Hair brushes should be washed and kept thoroughly clean, or otherwise they will simply return dirt to the scalp and hair.

5. Tight hats hinder the circulation of blood in the scalp and should not be worn. The best hats fit loosely and permit the free entrance of air.

6. Wetting the hair to make it smooth does harm by tending to cause decomposition at the roots of the hair.

LESSON III.

The Teeth.

Materials: human teeth; teeth of the ox cut open lengthwise to show the pulp cavity.

By the time a normal child is about six years of age, he has a set of twenty teeth—ten in each jaw. Of these, four are incisors, two are pointed or canine teeth, and fourteen are molars or grinders. All of them are known as "**milk**" or temporary teeth, because they are gradually lost and become replaced by a permanent

set, the first of which show themselves when the child is about six or seven years of age.[1]

The attention of pupils should be called to the small hole at the very end of the root. This admits the blood vessels and nerve to the **pulp cavity**[2] of the tooth. When a hole forms in a tooth nearly deep enough to reach the pulp cavity the tooth begins to ache.

Care of the Teeth.

1. Particles of food, especially food containing much sugar, decay through the action of bacteria,[3] and produce acids. These acids act upon the teeth and cause them to decay.

2. The larger particles of food that get between the teeth should be removed by a quill or wooden toothpick, after leaving the table.

3. Bacteria getting into cracks in the enamel cause decay of the teeth, and produce a cavity, which subsequently causes toothache.

4. Children with soft teeth should be encouraged to eat moderately tough or hard food. This will tend to harden the teeth.

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[1] The first incisors cut through the gums of an infant about the 7th month ; the second incisors about the 9th month ; the canines about the 16th month ; the first molars about the 12th month ; and the second molars about the 24th month ; but there are often wide variations from these periods.

[2] The pulp cavity is the central part of the tooth and contains the blood vessels, lymphatic vessels, and nerve supply. It has the general shape of the outside of the tooth, and the dentine is moulded round the cavity.

[3] Bacteria are exceedingly small plants, so small that they can only be seen by the aid of a powerful microscope.

LESSON IV.

THE TEETH.

Materials: different kinds of human teeth; a set of dog's teeth; a set of ox's teeth; or the lower jaw bones of different kinds of domesticated animals with the teeth in their sockets.

The teeth which an animal possesses are suited to its food and mode of living. Thus in cats and dogs the canine and bicuspid teeth are the main ones, and are used in tearing the flesh of their prey. These teeth are, therefore, chiefly pointed ones. On the other hand,

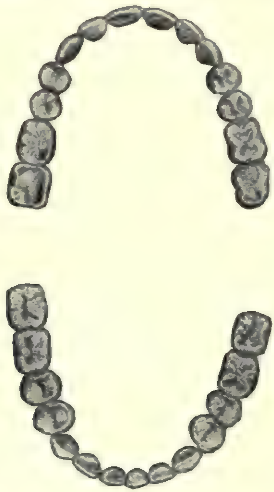

Fig. 7.—Permanent teeth not including the four wisdom molars. In one jaw, four incisors, two canine, four bicuspids or premolars, and four molars.

the molars or grinders, are prominent in cows, sheep, and horses. In rats, squirrels and beavers, the incisors are the prominent ones because they are used in cutting wood, opening nuts, etc.

The pupils should be asked to compare the teeth of a man with those of the dog and ox,[1] and to note resemblances and differences in the number and disposition of each kind. By the time a boy is 12 or 13 years of age he has a permanent set of twenty-eight teeth. Between 21 and 24 years of age, four additional molars grow back of the others. These are known as wisdom teeth and complete the full set of thirty-two.[2]

Care of the Teeth.

1. The permanent teeth should be examined twice a year by a dentist and any cavities should be filled.

2. The **milk** or temporary teeth should be cared for almost as carefully as the **permanent** ones. Any cavities in them should be filled by a dentist.

3. Tartar should be removed from the teeth at regular intervals.

4. Take care to employ a dentist who sterilizes his instruments before using them.

5. When teeth have been lost, they should be replaced with artificial ones, either by means of a "plate," or by "bridgework," preferably the latter where it can be used.

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[1] In the dog and the cat the molars partake of the pointed character of the bicuspid teeth. In the ox there are no incisors in the upper jaw, and there is only one pair of premolar teeth.

[2] The permanent incisors appear between the seventh and the eighth year; the canine, about the eleventh; the bicuspids or premolars between the ninth and tenth; the first molars about the sixth; the second molars about the twelfth, and the last molars, or wisdom teeth, about the twenty-fourth; but here again there are considerable variations in time.

LESSON V.

THE SKIN.

In beginning this lesson, certain problems about the structure and thickness of the skin may be propounded to the pupils. The following are suggested :—If possible find places on the hand on which the skin is thick, and other places where it is thin.[1] Can similar places be found on the face?

What occupations cause thickened skin **(callosities)** on the palms of the hands?

Scratch the skin with a clean needle, and then tell whether pain is felt first, or whether a tiny drop of blood comes first.

Give a reason for saying that the skin consists of two coats[2]—an outer one that causes no pain when cut, and an inner one that contains nerves and blood vessels. To prove that there are blood vessels, press the end of one finger firmly against the skin on any part of the hand, and a white spot forms underneath. Explain.

The outer layer of skin is the **epidermis**, or **scarf skin**; the inner one is the **dermis**, or true skin. The

[1] Generally speaking, the skin is thinner on the backs of the hands than on the palms. In the case of manual laborers this is very apparent, callosities being formed. The skin is equally thin on almost every part of the face.

[2] The epidermis of the palms of the hands and the soles of the feet can be pared off with a sharp knife or razor without causing any pain, or drawing any blood ; consequently we say that it is devoid of nerves or blood vessels.

epidermis is made up of many fine scales lying one upon another; these are being worn off at the surface and new ones are being formed underneath all the time.[1]

When a blister forms, the epidermis is separated from the dermis by a watery fluid which comes from the blood. If the blister be opened, which should not be

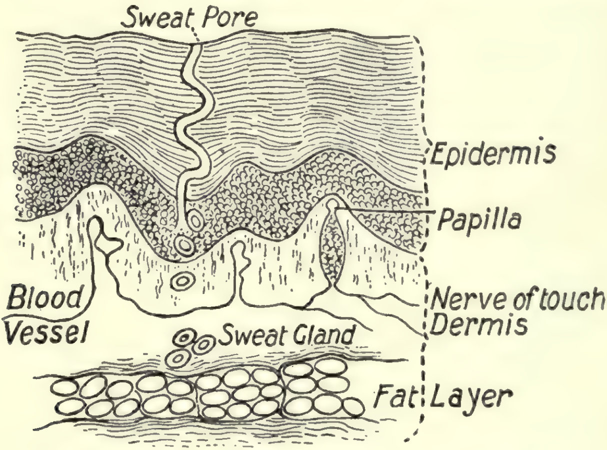

Fig. 8.—Diagrammatic vertical section of the skin.

done, the epidermis may be cut without causing pain; but the underlying dermis will be found to be very sensitive.

A **corn** is an outgrowth of the skin of the foot caused by ill-fitting shoes. A part of the skin that rapidly grows too thick is a **wart**; it is not due to pressure or friction as corns are.

[1] Dandruff is composed not only of the scales of the epidermis, but also of an excessive discharge from the oil glands of the hair.

CARE OF THE SKIN.

1. Warts, if let alone, will disappear in time.

2. All cuts, or bruises that break the skin should be washed, and the wound covered with a clean plaster or bandage to prevent disease germs from getting into the blood.

3. Pimples, boils or abscesses, should never be picked with a pin, nor opened with anything but a sterilized[1] needle or knife.

4. Absolute cleanliness is a cardinal principle in the surgical treatment of all wounds or sores, and cleanliness of wounds can only be secured by washing with water that has been well boiled. The sore should then be dressed with cloths and bandages which are scrupulously clean. If this is not done, the surgeon might be sowing the seeds of disease in a wound instead of helping to heal it.

LESSON VI.

THE EYE.

The external parts of the human eye having been taught, attention may then be called to the eyes of household pets for the purpose of noting resemblances to, and differences from, the human eye. In this way children will learn that the pupil in a cat's eye is larger than in a man's. It will, therefore, admit more light, and enable the cat to see objects in a dim light or at night better than a man can.

The use of other parts of the eye may also be taught. The eyebrows protect the eye from small objects

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A needle may be sterilized by placing it in boiling water for 20 minutes, or by heating it red hot in a lamp flame and then allowing it to cool.

coming from above, and they were probably more useful to savage than to civilized man.[1] The expression of the emotions (anger or surprise),[2] by movement of the eyebrows, are recognized by even young children.

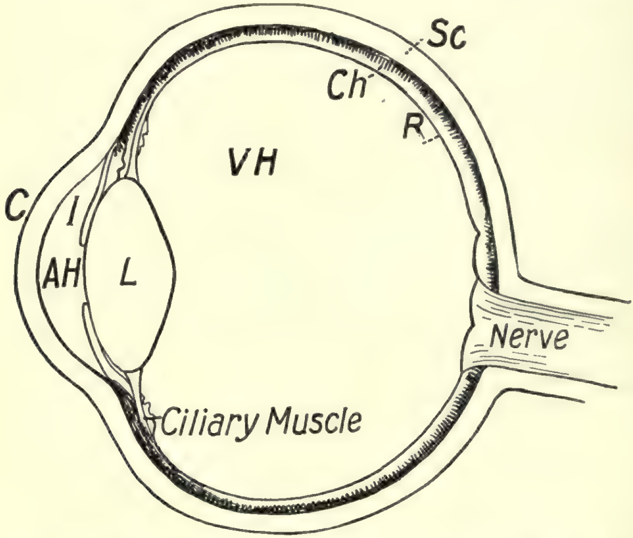

Fig. 9.—Diagrammatic front to back section through the eye. Sc, the sclerotic coat; Ch, the choroid coat; R, the retina, being the expanded end of the optic nerve; VH, the vitreous humor; L, the crystalline lens, surrounding this the suspensory ligament, and this attached to the ciliary muscle; AH, the aqueous humor; I, the iris, extending over the front of the lens, excepting the circular opening in front, the pupil; C, the cornea.

[1] In the case of savage men, living more in the woods than in the open, the eyebrows would help to protect the eyes from branches or small objects touching them from the front and above.

[2] Contraction of the eyebrows into a frown, as almost every child knows, expresses disapproval or anger. Elevation of the eyebrows expresses a question or surprise.

In addition to keeping out dirt particles, the eyelashes and eyelids help to regulate the amount of light entering the eye. The class may infer the function of the pupil by watching the changes that take place in its size on approaching a bright window, and then retiring to a dark corner of the room.[1]

Care of the Eyes.

1. Reading or study should not be done in a dim or flickering light. Too bright a light for such work is also bad for the eyes.

2. When we read, the head should be erect, and light should fall full upon the page. The proper reading distance is about fourteen inches from the eyes, but no type should be used which cannot be read at twenty inches. The book should be held nearly on a level with the eyes.

3. In writing, the light should come from the back and left, but not from the back only. Light from above is the best.

4. Some people lie in bed and read until they become sleepy. This habit is bad for the eyes.

5. In any occupation requiring a continuous strain upon the eyes, such as reading fine print or doing fine needlework, provision should be made for resting the eyes from time to time. The best way to rest the eyes is to look at a distant object every few minutes.

6. Reading in cars or carriages injures the eyes. The constant jolting interferes with the proper adjustment of the eyes.

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[1] On approaching a bright light the pupil contracts and diminishes the amount of light entering the eye. The opposite change takes place on retiring to a dark corner or room.

7. The habit of wearing thick or dotted veils may do harm to the eyes. A thin veil with a large mesh does not interfere with vision or do harm.

LESSON VII.

THE EAR.

A close examination of the outer ear will reveal the presence of hairs at the entrance to the meatus. Some of the brighter pupils may hazard a guess as to the

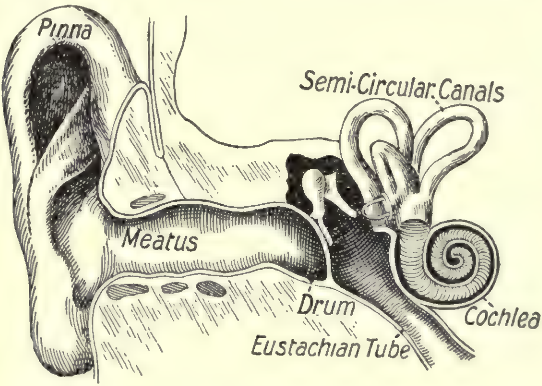

Fig. 10.—Diagrammatic representation of the ear. The outer ear extends from the pinna to the drum. The semi-circular canals and cochlea constitute the inner ear. The middle ear lies between, and is connected with the throat by the Eustachian tube. The cochlea is the true organ of hearing. The semi-circular canals form part of the mechanism for maintaining the equilibrium of the body.

function of these hairs, namely, to keep out small objects, including insects. Most pupils will have noticed the exit of particles of wax from the meatus, and they may

be told that this substance comes from small **wax glands** in the meatus, which closely resemble sweat glands.

In the case of frogs and some other familiar animals which have no outer ear, pupils may be asked how we know that such animals can hear.[1] Ask also which of the pupils in the class can move their ears. The muscles are present for moving the human ear,[2] but few persons possess the power of using these muscles.

Inside of the drum is a small cavity, the middle ear. This is connected with the **pharynx,** or back part of the mouth, by a fine tube, called the **Eustachian tube.**

Care of the Ear.

1. Wax sometimes hardens in the meatus and causes partial deafness. It should be removed by gently syringing with lukewarm water.

2. Pins or needles should not be used to remove wax, as they may pierce the drum and impair hearing.

3. Deafness is sometimes caused by a disease in the throat closing up the Eustachian tube. Impaired hearing in children should at once lead parents to consult a physician.

4. After bathing, swimming, or diving, water should be got out of the ear by a sidewise throwing movement of the head.

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[1] From the fact that an animal makes a noise, we infer that it can hear; but in corroboration of this, in the case of frogs and toads, we know that they can hear, because they can be frightened by noises.

[2] Three muscles are attached to the outer ear in man: the *attrahens*, *retrahens* and *attollens*.

5. Loud noises or explosions, or even excessive blowing of the nose may injure the ear and impair hearing.

6. Do not allow a barber to cut the hairs at the entrance to the meatus.

LESSON VIII.

Sense of Taste.

Materials: glass or porcelain buttons, clean silver coin, graphite, marble, wood, candy, table salt, quinine and vinegar.

In studying the sense of taste, children should be encouraged to try many of the experiments at home. Ask them to find out whether such solids as glass, or porcelain buttons, silver, graphite, marble, and wood have any taste. They will of course bring contradictory findings, but these should lead to further experiments. For example, most will agree that glass has no taste, some will be doubtful about graphite, and all will agree that wood has. These results will suggest the general question: How is it that some solids have a taste and others none? To answer this, ask the pupils to allow solid substances to stand in water for some hours and then taste the water. In this way the general conclusion may be reached that only those solids have a taste, which are soluble in the saliva. Or the statement may be put in another way: Liquids alone excite the sensation of taste. To verify this, ask pupils to dry the tongue thoroughly, and then place a piece of dry candy upon it. No taste will be at first experienced; but, as soon as a

little of the candy has dissolved in the saliva, the sweet taste will be felt.

The class should then be asked to find out in what parts of the mouth the sense of taste is located, and whether the different taste sensations can be classified. To answer these questions, solutions of sugar, salt, quinine and other substances should be made and applied with a camel's hair-brush or swab to various parts of the mouth—palate, cheeks, under surface of the tongue, tip and edges. In carrying out these experiments, only small quantities of the solutions should be used so that they may not be spread over the interior of the mouth. In testing the various parts of the tongue the organ should be protruded and the pupil should signify his answers by signs.

Tastes are usually classified into (1) sweet, (2) bitter (3) acid, and (4) saline, but pupils should not be discouraged from making a different classification if they can.

Having studied taste sensations, the class may next be asked whether we learn anything further about objects by placing them in the mouth. Can we feel smaller objects in the mouth by means of the tongue than by means of the fingers?[1] Can we estimate the temperature of a liquid better by taking a mouthful of it than by placing the finger in it?[2]

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[1]The tip of the tongue is a very sensitive touch organ. Two points (for example, those of a pair of compasses) can be distinguished as separate points more accurately by the tongue than by the tips of the fingers. See lesson on the sense of touch.

[2]The mouth is more sensitive to a change of temperature than the fingers.

LESSON IX.

Mastication.

Mastication is the act of chewing the food. To introduce this subject, children should be asked about the manner in which domestic animals take their food. Dogs swallow theirs at one gulp just as did their wild ancestors who hunted in packs. The quickest eater got the most food. Cats eat theirs leisurely as a solitary animal would.[1] Oxen graze the fields or woods for food and keep it in the mouth only long enough to moisten it for swallowing. Deer have the same habit, and after gathering enough food retire to some place of safety, where they lie down and chew the cud. This chewing is mastication proper.

The late Hon. W. E. Gladstone, Prime Minister of Great Britain, gets credit for the rule: "Thirty-two chews to a bite." If he ever gave this rule to anyone, Mr. Gladstone merely meant to emphasize the great importance of grinding the food between the teeth, until it was reduced to very small particles and thoroughly mixed with the juices of the mouth, the **saliva.** The digestion of the food *begins* in the mouth. If food is not thoroughly masticated, more of the work of digestion is thrown upon the stomach and small intestines than they should bear. The man, therefore, who "bolts" his foods is likely to suffer from indigestion in the course of a few years.

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[1] Cats, lions and tigers are solitary animals in the wild state; when they capture their prey, they retire to some quiet spot and eat it at their leisure. They are then not afraid of losing their meal by their fellows devouring some of it, as is the case with wolves and dogs

RULES FOR EATING.

1. Meals should be taken at regular periods, five or six hours apart, three times a day.

2. No food should be eaten between meals, because the stomach needs rest just as other organs do.

3. Delicate people should not eat when tired. They should lie down for twenty minutes or half-an-hour before eating.

4. People should not bring their worries and anxieties to the table. If they do, their food will not digest properly. Mealtime should be a time for fun, laughter, good stories, and pleasant conversation.

5. Some people seem to require four meals a day, especially if engaged in hard manual labor. Those who are recovering from a severe illness may be allowed five meals, if their digestion is good.

6. There is little danger from overeating, if plain food only is taken.

LESSON X.

DIGESTION.

Materials: the gullet and stomach of a cat or a rabbit.

Eating and mastication are really the first two steps in the general work of digestion. In this lesson it will be proper to ask in the first place why we eat. The children will answer readily enough that we eat because we are hungry. If the further question be asked: How do we become hungry? the children will be unable to answer. They must then be told that we become

hungry because little bits of our bodies are wasting away and dying all the time. This waste matter is carried by the blood to the skin, lungs, kidneys and intestines and thrust out of the body.

At this point a third question may be asked: How is it that we do not grow thinner all the time and lose weight? The answer will soon suggest itself. Because we take food. Then will follow the question: Does food after it enters the stomach pass straight into the flesh and blood of the body, or must it be changed? The stomach of a cat or rabbit may then be shown (Fig. 11) and it may be explained that the food which we eat is changed by the juices of the mouth, stomach and

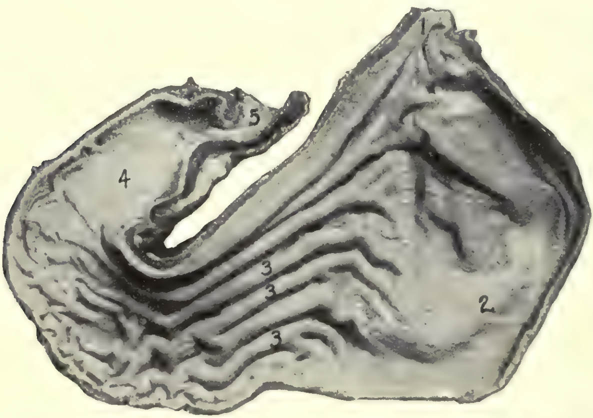

Fig. 11.—The inside of the stomach of a cat. 1. Opening of the gullet into the stomach; 2, large end of the stomach next the heart (cardiac end); 3, 3, 3, rugæ or wrinkles in the lining or mucous membrane; 4, pyloric or small end of the stomach; 5, opening from the stomach into the bowel or pyloric opening. When the stomach is full of food the rugæ disappear; that is, they become flattened out against the outer or muscular coat.

bowels into liquid substances that can pass through the walls of the intestines, enter the blood, and nourish the body.

Care of the Digestive Organs.

1. We should avoid drinking much liquid during a meal. Drinking tea, coffee or water dilutes the saliva and causes us to swallow food before it is properly masticated.

2. We should avoid foods that contain much vinegar or acids, because they stop or diminish the flow of saliva, and prevent its action on the food.

3. Alcohol irritates the inside of the mouth and stomach and impairs the effects of the juices upon the food. If the irritation be kept up, the stomach becomes incapable of doing its work. Alcohol should not, therefore, be taken along with food.

LESSON XI.

Breathing.

Apparatus: pair of large calipers; rubber bulb with a hole in it; distended lungs of the frog.

What different parts of the body can we see moving when we are breathing? Partly as a result of pure guesswork and partly by mistake, children will enumerate parts that move and parts that do not move.[1] The

[1] In respiration, the breast, abdomen, ribs, and shoulders are all seen to move. In some individuals the nostrils dilate slightly, but this is not usual. The soft palate moves also, and so does the opening into the windpipe, the glottis; but these movements cannot be seen by children.

answers should all be written on the blackboard and then the teacher should proceed to verify or disprove the answers in presence of the class.

To show changes in the size of the chest a large pair of curved calipers[1] should be applied from front to

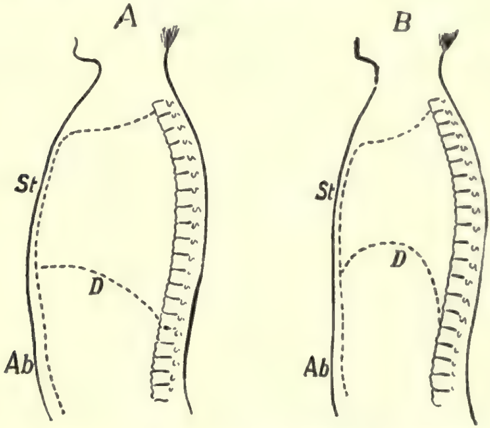

Fig. 12.—A, position of parts of the trunk in inspiration. B, their position in expiration. St, the sternum or breast bone. D, diaphragm, a muscular partition which separates the thoracic cavity from the abdominal cavity below. In inspiration the diaphragm descends, presses upon the stomach and bowels thus pushing out the abdominal walls, Ab, in front.

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[1] A simple pair of calipers can be made out of two umbrella ribs and their supports. Heat red hot seven or eight inches of the outer half of the ribs, then bend them into a curve. Now bind the two supports loosely together so that they may be used for adjusting the calipers. Fasten the inner ends together with a pin. One leg of the calipers should be applied to the breast and the other to the spine. Then ascertain by adjusting the calipers the difference in measurement (*a*) in inspiration and (*b*) in expiration. Use the calipers similarly in measuring the changes in the side to side diameter of the chest.

back and from side to side of the chest. This should be done first in **expiration** and then in **inspiration**, and the difference measured.

The teacher should then explain that just as the chest increases in size from front to back, and side to side; that is, during inspiration, about twenty cubic inches of air rush down the windpipe towards the lungs, and they expand. In inspiration the diaphragm descends and pushes out the abdominal walls (see Fig. 12); but, of course, this movement of the diaphragm cannot be seen in the unopened abdomen.

Since the chest decreases in size in expiration, the air is forced out again. The air, in fact, passes into the lungs and out again exactly as it does into and out of a hollow rubber ball with a hole in it, when the ball is compressed by the hand and released again.

Rules for Breathing.

1. The air we breathe should be the purest we can possibly obtain. Many diseases are the result of breathing impure air. Tobacco smoke renders the air impure and poisonous.

2. Breathing through the nose removes more of the dust particles than breathing through the mouth. It also warms the air better in cold weather. In this way the health of the throat, windpipe and lungs is promoted.

3. In either sitting or walking, the body should be kept straight, the shoulders thrown back, and the chest outwards. This gives the lungs free play in breathing.

4. In order to breathe properly we should not wear tight clothing round the body.

LESSON XII.

Bones.

Material: the leg bone of a fowl that has been soaked for 24 hours in a weak solution of hydro-chloric acid.

In the second lesson in the study of bone, we seek to find out the cause of its softness and toughness. Bones are made up of a compound of two kinds of substance. One of these is earthy or mineral matter, and the other is organic matter. The bones of infants have much of the tough organic matter in them, but not very much of the mineral matter. Their bones are, therefore, soft, not hard, and they are easily bent. Milk, which all young mammals live on at first, contains much mineral matter—lime salts—and these gradually give firmness and hardness to the bones. As children grow older, milk should still form an important part of their food. Children of very poor parents are often fed with food which lacks lime salts, and then they suffer from the disease called **rickets,** in which there is deformity and weakness of the bones.

The experiment which furnishes material for this lesson shows how the lime may be removed from a bone, leaving it more soft and pliable than at birth. It can now be tied into a knot. A piece of this bone, if torn off and teased out with needles, shows that its minute structure is a network of fibres or threads—the organic substance spoken of above.

Care of the Bones.

1. School seats should be of such a height as will allow the children's feet to touch the floor. This will

prevent the thigh bones from being bent with the weight of the feet.

2. Desks should be arranged so that children can sit erect while writing, and may not run the risk of acquiring curvature of the spine or stooped shoulders.

3. Vests (waistcoats) or waists, if at all tight, compress the ribs, diminish the size of the chest, and prevent the due expansion of the lungs. These articles of clothing should never be worn by young people.

LESSON XIII.

Bone.

Material: a number of bones that have been burnt over night in a hot furnace. Also a long bone that has been boiled in lye.

The bones which have been burnt over night bring out clearly the cause of the hardness. When removed from the furnace, it is found that the bones have lost weight. They must be handled very carefully because they are very brittle. This hard, brittle substance is the earthy or mineral matter of the bone. The organic substance has all been burnt out; the toughness of the bone is now gone.

This mineral matter goes on increasing in amount very slowly during the lifetime of each person. The bones of old people, therefore, are more brittle than those of young people. Some lime is also deposited in the walls of blood vessels of middle aged and elderly people. This renders them brittle and liable to be ruptured if they are subjected to any undue pressure of

blood, as in severe muscular exertion or the inhalation of chloroform or ether.

Burnt bone retains perfectly the shape of the original. Sometimes the burning process shows that a long[1] bone is made up of three parts, namely, a central shaft and two extremities; for, after removal from the fire, one or both extremities may fall away from the central shaft. Boiling a long bone in lye or caustic soda will bring about the same result. This fact must be kept in mind by the surgeon, because long bones often break along the line of union between the extremity and the shaft.

Care of Bones.

1. Girls should wear short skirts because these allow of free movement and better development of the legs.

2. Children should not be allowed to jump from any great height lest they injure their bones or joints.

3. Exposure to cold and wet should be avoided, because this frequently leads to a disease of the joints known as articular rheumatism.

4. Long continued indulgence in alcoholic liquors impairs the power of the periosteum[2] to repair fracture of bones.

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[1] Bones are usually classified as long, short, flat, or irregular. The arm and leg bones are examples of long bones; the wrist bones are examples of short ones; the shoulder-blade of a flat one; and the hip bone of an irregular one.

[2] The periosteum may be described as the tough tissue or skin which covers the bone.

LESSON XIV.

Movement.

Material: a muscle obtained from the butcher, if possible with tendon attached.

Enumerate the parts of the body that move. Now place these under two heads. Under the head "Willing," write the names of those parts of the body which move when we wish them to move. Under the head "Unwilling" write the names of other parts of the body that move whether we wish them to move or not. What parts of the body move when we are asleep?[1] What is it that makes the forearm bend at the elbow? To answer this question, bare the arm between the elbow and shoulder, clasp it round the middle part with one hand and then bend the arm backward and forward at the elbow. Tell what changes in size and shape take place in the flesh underlying the skin at the front of the arm. Use a tape measure to find out whether the girth of the arm at the middle becomes larger or smaller when it is bent.

Repeat the bending of the forearm, but before doing so, place the finger just above the angle of the elbow. At this point the tendon or cord of the muscle is felt. From these experiments it becomes clear that just as the forearm is bent towards the upper arm the flesh below the skin at the front of the upper arm becomes enlarged and hard. The skin takes no active part in

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[1] The parts that move in sleep are the parts that move in respiration and in the circulation of the blood. Of course the arms, legs, and, in fact, the whole body is often moved when we are asleep, and unconscious of the movements.

the movement. It simply rises because it is lifted by the swollen mass beneath. If the movement of the fleshy mass under the skin has been carefully watched and felt, up and down, as the arm is bent and rebent, it will be seen that the mass shortens and thickens, and in shortening, pulls on the cord which is evidently attached to one of the bones of the forearm. The shoulder being fixed, it is the upward pull on this cord that raises the forearm.

All our motions as in walking, moving the arms, lips, jaws, tongue, fingers, are brought about by **muscles,** of which there are over two hundred in the body.

A special part of the surface of the brain controls all our voluntary muscular movements. This part is roughly triangular in shape for each side of the brain, and is indicated in front of and below the word "Motion" in Fig. 5. This part of the brain is known as the **motor area.** From special parts of this area, nerve impulses pass out to voluntary muscles when we "will" to move parts of the body.

LESSON XV.

Ventilation.

Give a reason for saying that air is coming into a warm room all the time,[1] and that air is leaving it all the time. These questions can be answered best, when the weather is cold. To help children to answer, the teacher

[1] In cold weather, children easily discover that cold air is coming into a room all the time from around the window sashes. If the air is entering a room continuously, it must be leaving it continuously, but this exit is not so easily perceived by children.

should direct them to try an experiment at home, or the teacher may perform it in school.

Proceed as follows: Light a candle and place it in the crack formed by opening a door an inch or two. Place the candle first at the top of the door, and then at the bottom, and notice in each position the direction in which the flame is bent. Can an inward or an outward draught be felt with the hand?

In the winter time, ask the children to go to the windows and find where cold air is coming in. Where, in a school-room, do we find most warm air? Is it near the ceiling or near the floor? The answer may require the use of a ladder on which a pupil may mount to the ceiling, but even if it takes time and trouble, the point should be settled by actual observation.[1]

Ask a few pupils to leave the room for five minutes just before recess or noon, and then to return before the class is dismissed and report how the air in the room differs from that outside. If it smells "stuffy" it is unfit to breathe. It should be as fresh and sweet as the air outside.

Rules for Ventilation.

1. In summer time, both windows and doors should be open as much as possible. Each pupil in a school should have at least 300 cubic feet of air, and it should always be kept fresh.

2. In winter time, flues and windows should be arranged to allow fresh air to come in at one opening

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[1]Warm air rises to the top and upper part of a room. Cats have discovered this, because they will not sleep upon the floor of a room at night, but resort to chairs, tables or sofas, so as to escape the cold air that lies upon the floor.

and the stuffy air of the room to go out at a different opening, but people in the room should be careful to avoid draughts.

3. If people are sitting in a room in winter the temperature of the room should be about 68° F.; if they are walking about or working, the temperature need not exceed 60° to 65° F.

4. Special pains should be taken to ventilate living rooms which have been tainted with tobacco smoke.

LESSON XVI.

Sleep and Recreation.

Why do we sleep? Why do we need rest?[1] Can we rest in other ways besides sleeping? Some such questions as these should be written upon the board, and after pupils have had time to think them over, the answers also should be placed upon the blackboard.

Of course we sleep because we are tired. School children become fatigued by the mental labor of study and recitation, and by the bodily exertion of playing games and taking calisthenic exercises. Their minds become rested by recreation, and their bodies become rested by sitting or lying down. At night both mind and body rest in sleep.

Pleasant reading is one form of recreation which a boy may take. But he may also find recreation in rearing and caring for rabbits or pigeons; in gathering wild flowers in the fields and woods; in watching the

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[1] Periods of rest and activity are characteristic of all forms of life. Movement and rest follow each other alternately in both animal and plant life. In our climate, plants rest during the winter months; and associated with plants, many insects also.

ways of birds; in making a toy ship or a camera. Whatever the form of recreation is, it must be one in which he takes pleasure and which he adopts from choice—not from necessity, otherwise it is no recreation. A monotonous diet, monotonous round of toil, lack of recreation—all of which are characteristic of American farm life—combine to produce not a few cases of insanity every year.

Rules Regarding Rest.

1. Bed clothes should be warm but not too heavy. If the bed clothes are kicked off during sleep, it is usually an indication that the child is too warm. If there is danger of the child catching cold at night, pyjamas should be worn instead of night-gowns.

2. The foot of the bed should always be nearest the stove or other source of heat in a bedroom.

3. Ample fresh air should be admitted to bedrooms at night, and they should be thoroughly aired for several hours during the day.

4. It is a great mistake to prepare for an examination by sitting up late at night to study.

LESSON XVII.

The Nose.

The entrance to each nasal cavity is the **nostril.** The lower part of the cavity leading directly from the nostril back to the pharynx is the part along which air passes on its way to the windpipe and lungs. It is, therefore, often spoken of as the **respiratory region.**

The upper spaces of the nasal cavity inside of the nostril is the region of smell or the **olfactory region.** Over this region, the nerve of smell, the olfactory nerve, is spread out (see Fig. 5, Part I). In order to draw up into this region the fine particles that produce a faint smell, we "sniff the air;" that is, we draw the air into the nose in short, quick breaths.

A few questions will soon elicit from a class some uses of the sense of smell. They should be directed to watch a dog when he is "tracking" an animal, or his master. Why does man keep different kinds of dogs?[1] How do we learn that air is unfit to breathe? Does the perfume of flowers attract bees and wasps?[2] Get pupils to devise an experiment to find out whether ants can smell or not.

Care of the Nose.

1. Do not neglect a cold in the head. The sense of smell is lost sometimes through the effects of chronic catarrh of the nasal cavities.

2. If the passage of air through the nose becomes impeded, a physician should be consulted. This rule does not apply to an acute cold, when one nostril frequently becomes stopped up, but only for a short time.

3. Do not use snuff or apply any irritating ointments to the inside of the nose. This is particularly applicable to catarrhal remedies which contain cocaine.

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[1] Probably because he has found that different kinds of dogs are useful for different purposes. For example, the deerhound is specially good for tracking deer; the great dane for hunting wolves.

[2] Many insects are attracted by the colors and perfume of flowers.

LESSON XVIII.

THE TONGUE.

Material: a calf's tongue.

The class will readily recognize the skin or mucous membrane covering the calf's tongue, and on cutting it open they will see that the mass of the tongue consists chiefly of lean meat or **muscle** tissue. On close examination of the surface they will perceive the rough elevations which are called **papillæ,** and they may then be told that the nerves, which carry taste messages to the brain and enable us to taste things, end in and about these little eminences in minute organs called **taste-buds.**

Attention should be directed to the different forms and sizes of these papillæ, and the pupils may be asked to feel the surface of a cat's or a dog's tongue with the finger, and compare the form of the papillæ in these animals with the form of papillæ on their own tongue.[1] A hand-mirror may be used at their homes for the purpose of making observations on the tongue. In a

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[1] Three kinds of papillæ are found on the surface of the human tongue: circumvallate, fungiform, and filiform. There are eight or ten of the circumvallate situated in a V-shaped line at the base of the tongue. The fungiform are scattered chiefly over the sides and tip; and the filiform, the most abundant, are scattered over the whole upper surface of the tongue. These latter are probably tactile in function, the sense of taste being located specially in connection with the other two kinds. In cats, dogs, and carnivorous animals generally, many of the papillæ are sharp horny spines, curved backward, and are probably designed to scrape the last remnants of flesh off bones.

healthy person, the organ is a pinkish red color. If it is furred and whitish, the stomach is probably out of order and should be attended to.

Care of the Tongue.

1. No special rules need be given for the care of the sense of taste. As the taste-buds, the end organs of taste, are all located within the mouth, they are sufficiently protected from all ordinary sources of harm. If it be desired to discriminate between closely allied tastes, we must remember that the best temperature for the substance to be tasted is from 10° C to 35° C. Very high or very low temperatures limit the delicacy of the sense.

2. This sense tires easily, and consequently some little time should be allowed to pass between tasting one substance and a similar one, if it be desired to discriminate carefully between them.

3. Professional tea-tasters have educated this sense so as to be able to classify teas on the basis of quality and value.

4. This sense is impaired by indulgence in tobacco and alcohol. People, who have injured their sense of taste in this way, often use large quantities of salt, pepper, spices and mustard in their food to make it, as they suppose, taste right.

LESSON XIX.

Alcohol, a Poison.

Material: alcohol of 5%, 10% and 15% strength.[1] Fresh water animalcules; aquatic worms; gammarus; larvæ of the May fly, or musquito. Watch glasses in which to place the alcohol and animals.

The aim of a first lesson upon alcohol should be to show its effects upon animal life. This can best be done by immersing very small animals, such as can be found in most pools and ditches, in different strengths of alcohol in watch glasses and observing them. A magnifying glass will be found useful in making observations upon the smallest forms.

The two prominent effects of alcohol may be demonstrated upon these tiny creatures almost as clearly as upon human beings. When first placed in the solutions the movements of the animals become quite lively; illustrating what is known as the **stage of excitement.**

This is due to the stimulating or irritating effects of the alcohol. A stage of quietness soon follows, due to the sedative effects of the poison. If the animal is not removed from the solution, the sedative effects become more and more marked. After some time it passes into a deep sleep, known as narcosis. Death soon follows.

In some animals, for example leeches, a greyish coating is seen adhering to the skin after death. This coating is thrown out by glands in the skin as a

[1] Alcohol of these strengths can be made by adding 5 parts of absolute alcohol to 95 parts of pure water; 10 parts of absolute alcohol to 90 parts of water; and 15 parts of absolute alcohol to 85 parts of pure water respectively.

protection against the irritating effects of poisons, and is similar to the sticky, glairy material which forms in excess in saliva when we take whiskey or strong alcohol into the mouth.

The following is a record of actual observations made upon the animals mentioned:

Vorticella.—A number of these little animals were placed in a 5% solution of alcohol. At the end of four hours the movement of their cilia was very much lessened, otherwise they were quite normal. When placed in a 10% solution and watched under a microscope, all movement had ceased within seven or eight minutes. On being transferred to fresh water for twenty minutes, it was found that they were all dead.

A fresh lot when placed in a 15% solution seemed to be at once paralyzed, and did not revive on being returned to fresh water.

Paramœcium.—When the animals were placed in a 5% solution it was found that all movement had ceased within two minutes. Transferred to fresh water, they did not revive. In some of them, a sack or pouch formed at one side before death.

In a 10% solution they all broke up into granules within one minute after their immersion.

Aquatic Worms.—Immersion of these for twelve hours in a 5% solution resulted in a gradual reduction of their movements. In five minutes after they were transferred to fresh water they were as lively as ever.

A 10% solution caused cessation of all movement in six hours. Transferred to fresh water, the legs began to

move first, then the head, and within an hour the animals had completely recovered.

In a 15°/₀ solution the animals were all dead and curled up within three hours.

Gammarus.—One of them when placed in a 5°/₀ solution ceased to move in twenty minutes. Returned to fresh water it became quite lively again in five minutes.

In a 10°/₀ solution another gammarus ceased to move in four minutes, and on being returned to fresh water it revived in eight minutes.

In a 15°/₀ solution, a third specimen ceased to move inside of half-a-minute. Fresh water revived it in ten minutes. Three others placed each in separate solutions of 5°/₀, 10°/₀ and 15°/₀ for an hour and then returned to fresh water, revived in ten minutes, eighteen minutes, and thirty minutes respectively.

Larvæ of May Fly.—These seemed to resist the effects of alcohol in a more marked way than the other animals.

They seemed quite indifferent to a 10°/₀ solution. One of them lived twenty-four hours in a 15°/₀ solution, while another lived less than twelve hours. Evidently one animal was much stronger than the other.

This experiment illustrates admirably a fact that is well known to physicians, namely, that poisons and medicines rarely affect two individuals in precisely the same way. One man may pass into a drunkard's grave at a comparatively early age. Another may drink immoderate quantities of alcohol for years, or even to old age, before succumbing to its evil effects. How can

we explain this difference to young people? The best answer is the experiment just alluded to. Some animals inherit very strong bodies compared with others. The strong can endure the effects of poisons of all kinds much longer than the weak. It is just so with human beings. Some constitutions can resist the effects of alcohol for years, when others, not blessed with so much strength, succumb to its effects in a comparatively short time.

WHAT EMINENT AUTHORITIES SAY.

The lessons upon the effects of alcohol and tobacco may be further impressed upon pupils by reading to them quotations from the works of standard authors. The following are submitted as suitable for this purpose:

"Out of thirty-two young men in New York city who were recently examined for West Point Cadetships, only nine were accepted as physically sound. Such a note might well make the young men of our cities pause for a moment's thought. Beer, the cigarette, too much amusement, and the hidden vices are making havoc with the physical manhood of all our towns and cities." —*Journal of the American Medical Association.*

"Tobacco interferes with and impairs general development, physically and mentally, probably by retarding progressive cell changes and impairing nutrition."—*British Medical and Surgical Journal.*

"Total abstinence from alcohol and tobacco is required from all competitors while in training for athletic games and races. —H. NEWELL MARTIN, M.D., F.R.S.

"We find that those who injure their brains by tobacco, alcohol, and other kinds of intoxicants, at the same time bring on digestive troubles which cannot be cured until the causes are removed. Even tea and coffee are frequent causes of indigestion."—*Journal of Hygiene.*

"Alcohol is a slow but sure working poison that robs men of their physical and mental force, the more it takes the place of ordinary food."—A. BAER, M.D., *Royal Sanitary Commissioner, Berlin.*

"On salivary digestion, malt liquors have a very great retarding effect, especially when the saliva is quite dilute."—DR. CHITTENDEN and DR. MENDEL, *Yale University.*

"Nicotine paralyzes the activity of the nervous tissue."—MICHAEL FOSTER, M.D., F.R.S.

"Every dose of alcohol, even the most moderate, diminishes the strength. All a man asserts of the strengthening effects of alcohol is founded on delusion."—ADOLF FICK, M.D., *University of Würzburg.*

"Brimstone can be burned in the furnace of a steam engine; but it would not be a proper fuel, and would destroy the engine. So alcohol is not entitled to be called a food, as, even if burnt, it does harm to the apparatus."—LAUDER BRUNTON, M.D., F.R.S.

"According to the highest authorities, alcohol exerts an exceedingly deleterious action on rapidly growing tissues, interfering with their nutrition, and preventing the development of their proper function."—G. SIMS WOODHEAD, M.D.

"Alcohol is a typical stimulant; it acts as a whip, causing a temporary acceleration of physiological activity. Such acceleration must subsequently be paid for, the extra expenditure brought about by alcohol entailing diminished capacity for further exertion. Alcohol is thus of service only for emergencies of short duration; it is eminently harmful when prolonged exertion and endurance are required. Like all rapid stimulants, alcohol is in large doses a direct depressant."—PROF. WALLER, *St. Mary's Hospital Medical School, London, England.*

"Stunted growth has again and again impressed a lesson of abstinence from tobacco, which has hitherto been far too little regarded."—*London Lancet.*

"All alcohol, and all things of an alcoholic nature, injure the nerve tissues *pro tempore*, if not altogether, and are certainly deleterious to health. I think there is a great deal of injury being

done by the use of alcohol in what is supposed by the consumer to be a most moderate quantity, to persons who are not in the least intemperate, and to people supposed to be fairly well. It leads to degeneration of tissues; it damages the health; it injures the intellect. Short of drunkenness, that is, in those effects of it which stop short of drunkenness, I should say from my experience that alcohol is the most destructive agent we are aware of in this country."—SIR WILLIAM GULL, M.D., F R.S., *Consulting Physician to Guy's Hospital, London.*

"A party of engineers were surveying in the Sierra Nevadas. They camped at a great height above the sea level, where the air was very cold and they were chilled and uncomfortable. Some of them drank a little whiskey and were less uncomfortable; some of them drank a lot of whiskey and went to bed feeling very jolly and comfortable indeed. But in the morning the men who had not taken any whiskey got up in good condition; those who had taken a little whiskey got up feeling very miserable; the men who had taken a lot of whiskey did not get up at all; they were simply frozen to death. They had warmed the surface of their bodies at the expense of their internal organs."—PROFESSOR BRUNTON, *St. Bartholomew's Hospital, London, Lecturer on the Practice of Medicine.*

"The Sirdar, Lord Kitchener, and General Gatacre, in their advances up the Nile strictly forbade the supply of alcoholic liquors to any of the troops under their command. We learn that they took this step on two grounds. First on the ground that from long experience they were convinced that the physical condition of the troops would, under these conditions, be enormously improved, and the men would have much greater staying power; while their dash, determination and steadiness would also be increased. The second ground appears to have been that the mental and moral stamina of the troops would be preserved in a far greater degree than could possibly be the case if alcohol were served out. The result was that the health, spirits and conduct of the troops was the admiration of all those who had any dealings with them, and this experiment on a large scale was an unqualified success."—J. SIMS WOODHEAD, M.D., *Professor of Pathology in the University of Cambridge, England.*

PART III.

LESSON I.

The Hair.

Materials: the same as in Forms I and II, and in addition, small pieces of fur from different kinds of animals; quill feathers and down feathers.

How does fur differ from hair? Are the hairs on a cat's upper lip, the **vibrissæ**, the same as those on her back?[1] If not, how do they differ? Find two kinds of feathers on a bird. The large, hard feathers, **quills**, are used in flying; the small, soft ones, which cling closely to the body, are for keeping the bird warm: **down** feathers.

Look at a plucked fowl and tell whether there are any marks on the skin where the feathers grow. If so, are the feathers arranged in any order on the skin?[2] Are the hairs on the human arm arranged in any order? A study of "goose-skin" may help the pupil to answer this question. When taking a cold bath, everyone has

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[1] The vibrissæ are long, stiff hairs, popularly known as the cat's whiskers. They are organs of touch.

[2] The marks on the skin, showing where the feathers grew, are easily seen on any fowl from which the feathers have been plucked. The feathers grow out in a regular order on the skin, forming the feather tracts. The hairs on mammals also grow in regular tracts, the arrangement of which on a man's arms is similar to that on the monkey's.

noticed this condition. It is caused by the contraction of the small muscle fibre which is attached to each hair follicle.

Why does hair fall out early in life in some men and not in others?[1] Why does hair turn grey? Why is baldness more common in men than in women? Savages who go bareheaded do not become bald.

Care of the Hair.

1. Vigorous people should not wear heavy hats in summer, nor warm, heavy caps in winter. Delicate people may be compelled to do so.

2. If the roots of the hair die, baldness results. No "Hair Restorer" of any kind will make hair grow upon a bald head. Shampooing, brushing, rubbing of the scalp, and the maintenance of good general health are the only means of preserving the hair.

3. Do not use the combs or brushes provided in a public wash-room. They are sometimes the means of communicating diseases to the scalp.

4. Make sure that your barber uses combs, brushes, razors, and scissors that are kept scrupulously clean.

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[1] Hair falls out early in some men because they have inherited this peculiarity from parents or near relatives. In other men, the hair falls out early because it has not been properly cared for. In some cases it falls out as a result of disease, for example, after fevers. Baldness is more common among men than women, probably because of the tight-fitting and heavy hats and caps worn by men. Hair begins to turn grey on the temples at about forty years of age. When the coloring matter ceases to form, the hair is white.

LESSON II.

THE SKIN.

The total surface of the skin on a man varies from 16 to 18 square feet. Its thickness varies in different parts of the body from the $\frac{1}{100}$ to $\frac{1}{8}$ of an inch. The true skin consists of a network of connective tissue fibres, muscle fibres, small blood vessels, and nerve fibres, all woven closely together. Here and there in the network, are small masses of fat, and adjoining the fat masses, are numerous very small sweat glands. These probably average as high as 2,500 to every square inch of skin. The quantity of sweat given off every day from this immense number of glands is quite large; but, it varies with the food, drink, temperature of the air, and season of the year. It has been roughly estimated as amounting to about one and a half pints, or 800 grams per day. Sweat serves two useful purposes: (1) it evaporates and keeps the body cool in warm weather; and (2) it carries out of the body waste matter, which is no longer of any use and which, if not thrust out, would poison the system. This waste matter is dissolved in the liquid sweat and amounts to about eight or ten grams daily.

Hairs and nails are simply outgrowths from the skin. Joined to the roots of the hair are small glands which secrete an oily semi-liquid material, which protects the skin and hair. Sometimes the mouths of these glands, especially on the face and back, become closed. When this happens, the secretion hardens and forms a pimple with a cheesy-like mass within. If dirt enters the

mouth of the duct, the pimple is then known as a **blackhead.** These frequently indicate lack of vigor, and, in treating them, the main thing is to improve the general health, and especially the circulation of the blood through the skin.

None of the so-called "skin beautifiers," "skin foods," or "skin tonics" are of the slightest use in improving the complexion. Face massage, when skilfully done, will quicken the circulation of blood to the skin, and will consequently tend to remove pimples and keep away wrinkles, but face ointments are quite useless; often they are harmful.

Superfluous hairs can be removed by an electric needle applied to the root of the hair so as to kill the follicle. Pulling out superfluous hairs from the skin of a person in vigorous health will remove them for a short time only. They will grow again.

LESSON III.

Touch.

Materials: a pair of blunt-pointed compasses.

The skin is the organ of our sense of **touch,** of **pressure,** and of **temperature.** When an object touches our body at any point, impulses or messages start in the skin and travel along nerves to the brain and give rise to the sensation of touch or pressure. In the same way, if an object warmer than the skin or colder than the skin comes into contact with our body

impulses or messages travel to the brain along a different set of nerve fibres, and we have a sensation of warmth or cold as the case may be.

The sense of touch varies in different parts of the body. It may be tested by blindfolding one of the pupils, and then touching various parts of his body with a pair of blunt-pointed compasses. Bring the two points close together and place them on the tip of the tongue. When very close together they will feel as one point; when separated a little, the two points will be recognized as distinct. Measure this distance and record it on the blackboard. Try a similar experiment on the tips of the fingers; on the palm and back of the hand; and on the front and back of the forearm. After testing these various parts, arrange the results in order, beginning with the least distance that the compass points were apart and ending with the greatest.

Use another pair of compasses with blunter points. Warm them to, say 150° F., and test various parts of the body for sensitiveness to heat. By cooling the compass points down to 30 or 40° F., the sensitiveness of different parts of the skin to cold may be tested in a similar manner.

Touching the hair on the head or other parts of the body excites the sense of touch, not because the hairs themselves are sensitive, but because movement of the hair starts impulses in the nerve fibres connected with the root of the hair. In cats, rats and moles the hairs on the nose and lips are delicate organs of touch.

The sense of **pain** must be distinguished from that of touch. The same nerve may carry to the brain both kinds of impulses, but in the case of touch the impulse is weak, and in the case of pain the impulse is very strong; in other words, the nerve is strongly excited. It is believed that the sense of pain may be excited in any nerve which carries impulses to the brain. If the pain is slight, we can easily locate it; if intense, we cannot do so.

LESSON IV.

BONES.

Materials: long bones; a flat bone, for example, the scapula; and ribs. Some of these should be cut across and some cut lengthwise; wrist bones.

In this lesson, children should be encouraged to bring bones from their homes and to make observations on these for themselves. The "skin," or **periosteum** of the bone should be noted; the small hole or holes for the blood vessels which enter the bone; the smooth ends covered with gristle, or cartilage; the enlarged heads for the attachment of muscles; the hollow in the long bones, and the spongy texture of the inside of the short bones and ribs—all these points should be brought out by judicious questioning. Why are the bones hollow or spongy, and not solid? Would solid bones be stronger? To aid in answering these questions, ask whether the frames of bicycles are made of solid or hollow iron

bars. Ask also why the stems of grass, wheat, etc., are hollow.

In this way the pupils may be brought to see that hollow or spongy bones combine the two great qualities of lightness and strength. By the bones being hollow or spongy the greatest possible strength is obtained with the smallest possible quantity of material.

The cartilage at the ends of bone serves two purposes. It furnishes smooth surfaces by which the ends of bones move over each other without friction where there is much movement at a joint; and it acts also as a "buffer," and by its elasticity lessens the jar in any vigorous movement, such as striking, running, or jumping. The small openings into the bone admit the blood-vessels, so that the bone gets the nourishment which it requires. Finally, the movements of the body as a whole, and the movements of the parts of the body, such as the hands, arms, or feet, are all brought about by muscles contracting and pulling on the bones; the bones have accordingly enlargements at their extremities, or ridges along their length by which muscles can be attached.

The periosteum nourishes the bone; when it is removed the bone dies. The growth of new bone takes place from the inner surface of the periosteum. In the case of long bones, growth in length takes place between the shaft and the two extremities (see Lesson XIII, page 48).

LESSON V.

Chest and Abdomen.

Material: the opened chest and abdomen of a cat or rabbit.[1]

The cavity inside of the trunk is divided into two parts, the upper, known as the chest or **thorax**, and the lower, the **abdomen**. The muscular partition which separates these two parts is the diaphragm. The chest contains the lower end of the windpipe, most of the gullet, the heart, lungs and large blood vessels. The abdomen contains the stomach, liver, spleen, pancreas, small and large intestines, kidneys and urinary bladder. While the chest and abdomen are frequently spoken of as cavities, they are not in reality cavities at all. They are almost completely filled with the organs mentioned. Any space, not occupied by the above-named organs, is filled with a fluid which oozes out from the small blood capillaries. This fluid acts like oil in a machine. In the thorax, it prevents any friction or rubbing between the lungs and the chest walls. In the abdomen, it promotes the easy movement of the stomach, liver, kidneys and intestines against each other, or against the abdominal walls.

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[1] This experiment should be prepared by the teacher an hour or two before it is needed for the class demonstration. The animal should first be killed by placing it in a small closed box with chloroform enough poured upon a piece of cotton to ensure death. The chest and abdomen may then be opened along the length of the ventral surface of the animal. Teachers should not use charts for teaching any of these lessons. Charts are frequently very misleading, unless the natural objects have first been seen by the pupil.

The pupil should place his ear against the chest-walls of another pupil, and listen to the sounds which can be heard. The beats of the heart, and the sounds which it makes in beating, can be heard quite easily by placing the ear about three inches below the left collar-bone, and about two inches from the mid-line of the chest. Two sounds are heard, and these are usually represented by the syllables, *lubb dupp*.

If we listen at any other part of the chest, we can hear a soft blowing sound with every breath we draw. This is caused by the air passing down the larger bronchial tubes towards the air sacs of the lungs and up again.

It is by knowing these sounds of the heart and lungs, when they are in a healthy condition, that a physician can tell when these organs become diseased ; because, in disease, these sounds are either absent or altered.

Pupils should also learn the position of the stomach, liver and kidneys. The stomach lies immediately beneath the end of the breast bone. The liver lies to the right and a little above the stomach, and extends also behind the back and across to the left side. The kidneys lie, one on each side of the spine, just above the small of the back. Neither liver nor kidneys are stationary ; they rise and fall with every breath we draw.

LESSON VI.

Breathing.

Material: the "pluck" of a sheep, or similar parts of a cat or rabbit.

We must be careful to distinguish between the **mouth** and the **throat.** The mouth when open is the large cavity having the tongue for its floor, the cheeks for its two sides, and the **palate** for its roof. Back of the mouth is the throat or **pharynx.** The entrance to the throat is marked by a soft piece of flesh which hangs from the back part of the palate. This small finger-like piece of flesh is known as the **uvula.** On each side of the uvula are two soft roundish bodies, the **tonsils.**

Leading downwards from the throat are two tubes, placed one in front of the other. The front one is the windpipe. The upper part of this tube can be felt on the outside of the neck as a hard lump, popularly known as Adam's apple. Physicians call it the **larynx.** The hind tube is the **gullet** or œsophagus. These parts can easily be identified by referring to Fig. 14.

The passage from the throat into the larynx is guarded by a tongue-shaped covering, the **epiglottis.** When we swallow food, the epiglottis closes over the entrance to the larynx, and prevents the food from going down the windpipe. Immediately after the food is swallowed the epiglottis rises, and the windpipe is again open. Sometimes a little food "goes the wrong way;" that is, goes down the windpipe instead of the gullet, and then we have a fit of coughing. This is nature's way of expelling any solid matter from the windpipe. The windpipe is made up of a number of incomplete rings of cartilage, Fig. 13. These rings keep

the sides of the tube wide open, so that the air can enter and leave the lungs quite freely. The rings can be felt on the neck just below "Adam's apple."

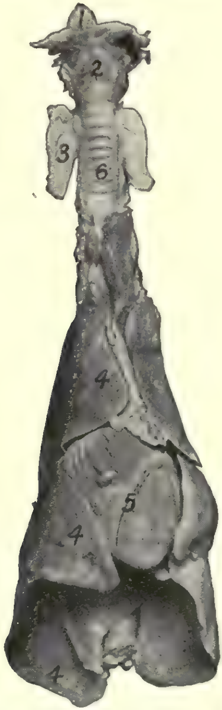


Fig. 13.—Front view of the lungs, heart and windpipe of a cat in their natural relative positions. 1, the epiglottis covering the entrance to the windpipe. 2, the larynx or enlarged end of the windpipe. It contains the vocal cords. 3, the thyroid gland, each lobe dissected off the windpipe. 6, the trachea or windpipe, shewing the cartilaginous rings placed edge to edge and extending downwards. 4, 4, 4, lobes of the right lung. Corresponding lobes are seen in the opposite left lung. 5, the heart. The diagonal line upon which the figure 5 is placed marks the boundary between the right ventricle of the heart and the left ventricle.

As the windpipe enters the chest it divides into two branches, one conveying air to the right lung, the other to the left. Within the lungs these tubes, called **bronchial** tubes, branch and re-branch again and again, until finally they end in little groups of small rounded **sacs** or **air chambers.** Each lung is, in fact, like a sac which has been divided and sub-divided by many partitions so as to form numerous small chambers. In the frog's lungs, the partitions of the sacs stand out from the walls only a little distance; but, in birds and higher animals, the partitions are exceedingly numerous and sub-divide the whole lung into many small chambers.

In the walls of these chambers are minute blood-vessels. As the blood passes through these minute blood-vessels, it takes oxygen out of the air in the air chambers and gives up carbon-dioxide to the air in the air chambers. When the blood comes to the lungs it is known as **venous** blood; when it leaves the lungs it is **arterial** blood. Arterial blood is of a bright red color, and distributes oxygen to every part of the body; venous blood is dark red in color and contains the gas, carbon-dioxide, gathered up from the tissues.

Rules for Breathing.

1. Be careful not to attempt to swallow any large piece of solid food, especially when drawing in the breath. Occasionally a person is choked to death in this manner.

2. Snoring is caused by the vibration of the soft palate (see Fig. 14) in breathing with the mouth open. It can be prevented by placing a bandage round the chin and top of the head; but, when this is done, the nose passages should be perfectly free or else the bandage should not be put on.

LESSON VII.

The Throat and Alimentary Canal.

Material: the gullet, stomach, and intestines of a cat or rabbit.[1]

It will be noticed that the mouth is not a large cavity when shut. The tongue touches the hard palate, the cheeks rest against the teeth, and there is then very little unoccupied space in the mouth.

The upper part of the throat is connected with each nasal cavity by two openings, and each nasal cavity opens to the outside by the nostrils. From the back and upper part of the throat are two tubes, each extending upwards to a space inside of the ear drum, known as the middle ear (see Fig. 10). These tubes transmit air to the middle ear every time we swallow.

There are thus seven openings from the throat: one to the mouth, one by the windpipe to the lungs, one by the gullet to the stomach, one to each nostril, and one to each middle ear. The relation of all these parts can easily be made out by a study of Figs. 14 and 5.

The alimentary canal, or digestive tube, is between twenty-five and thirty feet long in man, and extends from the mouth downwards. Its principal parts are the stomach, the duodenum, the small intestine, the large intestine. The lower part of this is called the rectum. All these parts should be examined and identified by opening the thorax and abdomen of a cat or rabbit.

[1] The material for this and for all similiar demonstrations should be prepared beforehand by the teacher, and preserved in alcohol or formalin of about 2% strength.

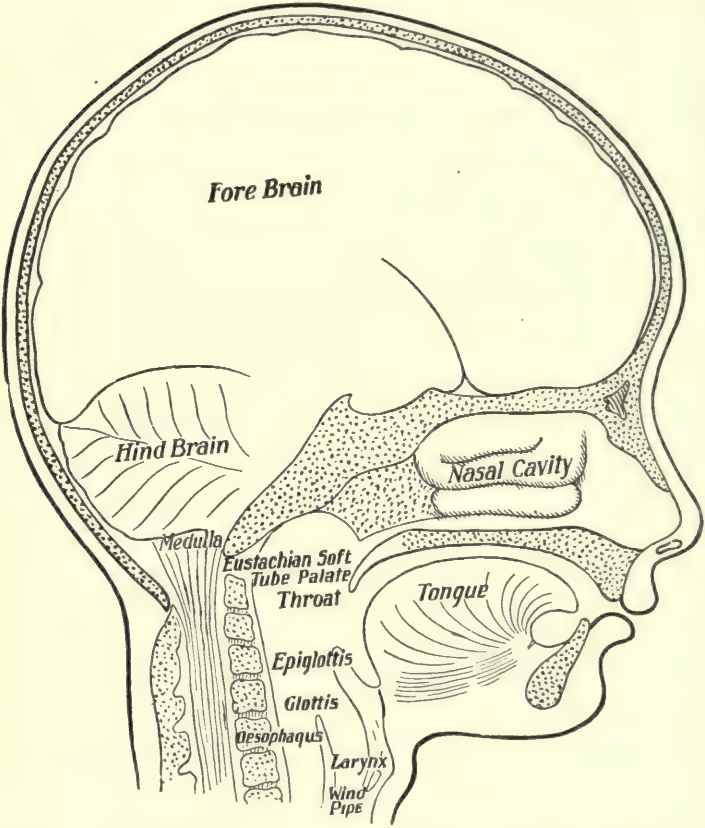


Fig. 14.—Diagrammatic front to back section through the head. The glottis is the opening into the larynx ; the epiglottis is the tongue-like covering which closes the glottis when we swallow. The soft palate is the flesh at the back part of the roof of the mouth, and along with the hard or bony palate separates the mouth cavity from the nasal cavity. The Eustachian tube should not be shown as opening into the medulla ; it opens into the middle ear (see Fig. 10). Consult also Fig. 5.

Roughly speaking, the walls of the canal consist of three layers, an outer muscular layer, a middle submucous layer, and an inner mucous layer. These layers are shown in Fig. 15. The inner one is thrown into folds or

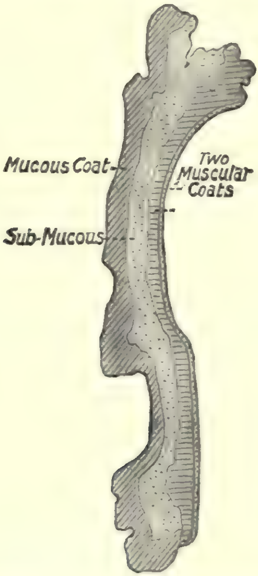


Fig. 15. — Diagrammatic cross-section through the wall of the stomach. The mucous coat is represented as wrinkled, or thrown into folds.

rugæ, and contains an immense number of small glands which furnish the gastric juice. The middle coat carries the larger-sized blood-vessels and the nerves ; and the outer coat, by its contractions, causes the various movements of the stomach, which occur during the digestion of the food.

Care of the Throat.

1. When we "catch cold" in the head, the skin or mucous membrane of the throat usually becomes red and slightly swollen. This condition may extend along one or more of the seven openings. The tonsils may become considerably swollen, and cause pain in swallowing food. White patches sometimes make their appearance. When this occurs in children, a physician should be promptly called in to examine the throat.

2. After brushing the teeth every morning, the mouth should be rinsed. If mucus has accumulated in the throat, it should be gargled with salt and water, a weak solution of listerine, or some similar disinfecting solution.

3. The habit of smoking tobacco sometimes produces a disease of the throat, known as "smokers' sore throat."

LESSON VIII.

Food.

Ask pupils to enumerate the articles of food that are used upon most of our tables. Then tell them that our foods contain many different substances, but that they may all be classified under the following five heads:

I. **Proteids,** like

(*a*) albumen, or the white of egg.

(*b*) myosin, from lean meat.

(*c*) casein, or curds from milk.

II. **Fats,** like butter, lard, suet, olive oil.

III. **Carbo-hydrates,** like starch, sugar, etc.

IV. **Salts,** like table salt.

V. **Water.**

Explain further that inasmuch as substances like these are wasting away and dying in our bodies every moment we live, we must eat such food as contains these substances in order to keep alive and well, and we must eat them in proper proportions. A diet that consists solely of meat is not a wholesome diet. Nor is a carbo-hydrate diet a wholesome one. A man would soon starve to death on a purely starchy or fatty diet. Consequently we must have some standard by which we can select from the various foods those articles which best suit the natural needs of the body. We cannot leave the selection to the sense of taste. If this were done, children and those who have no self-control would soon make themselves ill by an improper selection of food. An excess of candies, preserved fruits and probably pastry would be eaten, and dyspepsia and finally indigestion would be the result.

Milk is the only article which contains the foodstuffs in the proportions required for the needs of the growing body. It is the only perfect food for the young. They can live on milk for a longer time than on any other one article of diet; that is, milk is the only substance which contains the proteids, fats, carbo-hydrates, salts and water in the proportions which are required for the proper nutrition of the growing body.

The proper quantity of food to be taken varies very much in different individuals, and varies in the same individual under different circumstances. Those who do hard manual labor require more food than persons of sedentary habits. A man who is poorly fed cannot stand hard labor. We require more food in cold weather than in hot weather, the extra food being used up in

producing heat. Young people require more food than adults, the additional food, beyond that required to make good the continual waste, being used for the development of the growing body.

LESSON IX.

Foods.

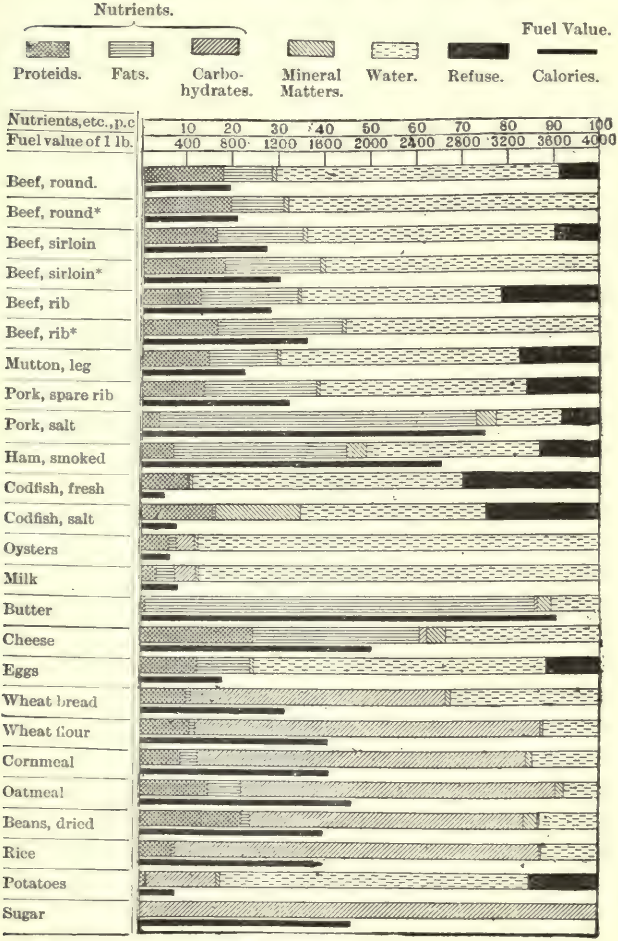
When people are young and strong they may pay no special attention to the choice or cooking of their food; but, if they disregard all care in its selection and preparation, later on in life they are likely to pay the penalty of their carelessness or ignorance.

The following table shows the proportions of proteids, fats, carbo-hydrates, salts and water present in most of our common articles of food. The pupil should compare each of them with Ranke's standard diet and see what each article lacks in order to supply the different substances required by the body. Ranke's diet consists of about three per cent. of proteid, three per cent. of fat, nine per cent. of carbo-hydrate, and eighty-five per cent. of water; but according to other authorities, one per cent. of proteid is sufficient if a larger amount of carbo-hydrate or of fat is eaten. Salt is usually taken in quantity to suit the taste.

Another useful exercise for the pupil is to consider how a lack in one article of food might be remedied by combining it with some other article. For example, beef steak contains very little of the carbo-hydrates. This may be remedied by combining bread with it, and so on, with other foods.

COMPOSITION OF FOOD MATERIALS—(*Atwater*).

Nutritive Ingredients, Refuse, and Fuel Value.



* Without bone.

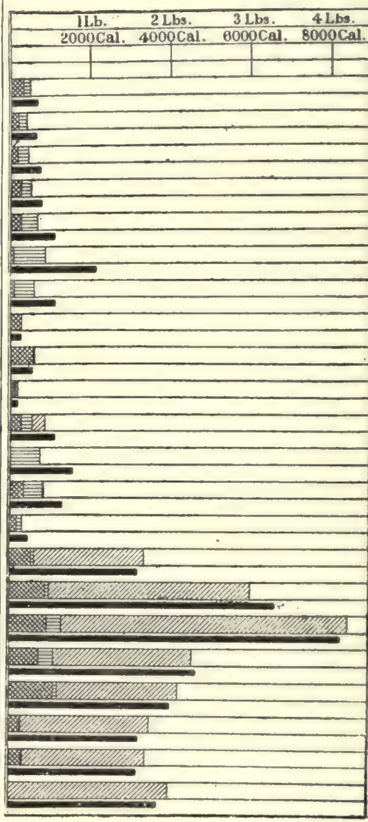
PECUNIARY ECONOMY OF FOOD—(*Atwater*).

Amounts of actually Nutritive Ingredients obtained in different Food Materials for 10 cents.

Proteids. Fats. Carbo-hydrates. Fuel Value.

	Price per pound.	Ten cents will buy—
	Cents.	*Lbs.*
Beef, round	12	.83
Beef, sirloin	18	.55
Beef, rib	16	.63
Mutton, leg	12	.83
Pork, spare rib	12	.83
Pork, salt, fat	14	.71
Ham, smoked	16	.63
Codfish, fresh	8	1.25
Codfish, salt	6	1.67
Oysters, 40 cents quart	20	.50
Milk, 6 cents quart	3	3.33
Butter	24	.42
Cheese	16	.63
Eggs, 25 cents dozen	16⅔	.60
Wheat bread	4	2.50
Wheat flour	2½	4.00
Cornmeal	2	5.00
Oatmeal	4	2.50
Beans, white, dried	4	2.50
Rice	5	2.00
Potatoes, 60 cents bushel	1	10.00
Sugar	5	2.00

Pounds of Nutrients and Calories of Fuel Value in 10 cents worth.



Of course, in planning the substitution of one kind of food for another, the question of economy comes into consideration. The foregoing table will enable the pupil to see how the cost of a meal may be made to vary according to the substitution that may be decided upon.

In a similar manner, the pupil should be led to consider what articles could be substituted for some other article, in order to secure variety in diet and avoid the bad effect which a monotonous diet has upon the system.

Next in importance to securing food in adequate quantity and proper proportions, comes the question of the digestibility of the different kinds of food. If we are strong and well, we may eat some foods that are hard to digest, but as a general rule it is not wise to do so. No definite rules can be laid down as to the digestibility of different foods. A food that proves indigestible to one person may not be so to another. Each person must discover those articles which are indigestible to him and avoid them for the future. The following table contains the foods that are relatively easy, and those that are relatively difficult to digest; but, in neither column are the foods arranged in the order of their digestibility.

Relatively Easy to Digest.	Relatively Hard to Digest.
Milk.	Fried meats.
Bread.	Beans.
Rice.	Peas.
Raw oysters.	Hard-boiled eggs.
Boiled beef.	Pork.
Mutton.	Veal.
Boiled chicken.	Cheese.
Broiled meats.	

LESSON X.

Mouth and Stomach Digestion.

Digestion means the changes which the food undergoes before it passes into the walls of the intestine and enters the blood. Once the digested food gets into the blood, it is carried throughout the body and used in nourishing the various parts.

Digestion is begun in the mouth. The saliva produces the first change, but it acts only upon starchy food such as the principal parts of bread, oatmeal, rice and potatoes. Starch cannot pass through the mucous coat of the stomach or intestine and enter the blood. It must first be changed into a kind of sugar. If we chew a piece of bread well for a few minutes, and then keep it in the mouth for a few minutes longer, we can notice that it becomes slightly sweet. Starch will not dissolve in water ; sugar will dissolve, so the change from starch to sugar is a change which permits this food to pass into the wall of the intestine and thence into the blood.

The other great use of saliva is to soften and moisten the food, especially dry food, so that we can easily swallow it.

If the food has been properly masticated, the saliva continues to act upon it for about thirty-five minutes after it has reached the stomach. During this time the stomach is adding another juice to the food, namely, the gastric juice. This juice acts upon a different kind of food from that on which the saliva acts. It gradually stops the action of the saliva, and then changes part of the proteid foodstuffs into compounds known as peptones

—a condition in which they will the more readily be absorbed through the intestinal wall. Complete mixture of the gastric juice with the food is brought about by contraction of the muscular walls of the stomach.

When the stomach is empty its mucous coat is thrown into folds or rugæ through the contraction of its muscular walls. These are shown in Fig. 11, Part II. As the stomach fills with food these rugæ disappear, and the mucous coat pours out the gastric juice. After remaining in the stomach for a time that varies very much in different persons, namely, from one-half to three hours, the food is passed through the pyloric opening into the duodenum, and it is then known as **chyme.**

Care of Digestive Organs.

1. Tight clothing should not be worn, because it interferes with the normal healthy movements of the organs of digestion and lessens the blood supply to them.

2. Alcohol should not be taken with the food because it slows digestion. If used in this way for some years, even in moderation, it is likely to bring on stomach indigestion.

3. Tobacco smoking is apt to disorder stomach digestion. It does this by causing an excessive flow of mucous saliva and gastric juice, and by benumbing the sensibility of the nerve endings of the stomach.

LESSON XI.

Intestinal Digestion and Absorption.

On leaving the stomach, the food enters the uppermost part of the intestine, the duodenum. Here it meets with two other juices: bile from the liver and pancreatic juice from the pancreas. Under the influence of these juices, more of the starchy food is changed to sugar, and more of the proteid is changed into peptone. Here also the fatty food is acted on and changed so that it can be absorbed into the intestinal walls. These various changes in the food have the effect of giving it a milk-like appearance, and it is now known as **chyle**. In this condition, much of it is now ready for absorption. The remainder is further acted on by a fifth juice from the walls of the intestine, the intestinal juice.

Now, the combined effect of the different digestive juices is to convert the more or less insoluble foods into liquid forms which will readily pass through the lining of the intestine and thence into the blood. A substance which cannot be rendered soluble by the digestive juices cannot be considered a foodstuff. It will leave the body as indigestible material.

Absorption.

Very little absorption of chyme takes place into the stomach walls. Most of the food is absorbed in the small intestine. In passing into the walls of the canal toward the blood and lymphatic vessels the food undergoes further change. The living cells which form a very thin covering over the whole length of the intestine

selects certain materials from the chyle, and changes these into other forms that render them more suitable for nourishing the blood and tissues. These changes are considered to be a further stage in the general process of digestion.

It never happens that all the food is digested in passing along the alimentary canal. For example, on the average, about 5% of meat remains undigested; about 9% of milk; 4% of white bread; 15% of brown bread; 4% of rice; 4% of macaroni; 7% of corn bread or porridge; 9% of peas; and 11% of potatoes. But it must be remembered that these percentages will vary much in different people, depending upon the quality of the cooking, the kind of meal of which they form a part, and upon the digestive apparatus of the eater.

Care of Digestive Organs.

1. A certain residue of undigested food is necessary in order to start muscular contraction in the walls of the intestine, and to maintain the bowel in a healthy condition.

2. Food and drink should be taken at about blood-heat. Very hot foods or hot drinks irritate the mucous membrane of the stomach and alter the normal digestive juices; very cold ones delay the secretion of the gastric juice and slow its action upon the food.

3. Spices, pepper, curry, mustard and all similar substances should be largely avoided.

4. Exercise or work in the fresh air will always give a healthy man a good appetite.

LESSON XII.

THE LIVER.

Materials: the liver of a sheep; part of the mesentery of a sheep, cat, or rabbit.

Three facts seem to indicate that the liver is a very important organ: (1) it is the largest gland in the body; (2) about one-quarter of the whole of the blood is present in it; and (3) nearly all the proteids, sugar, salts and water which are absorbed from the intestines are first carried to the liver.

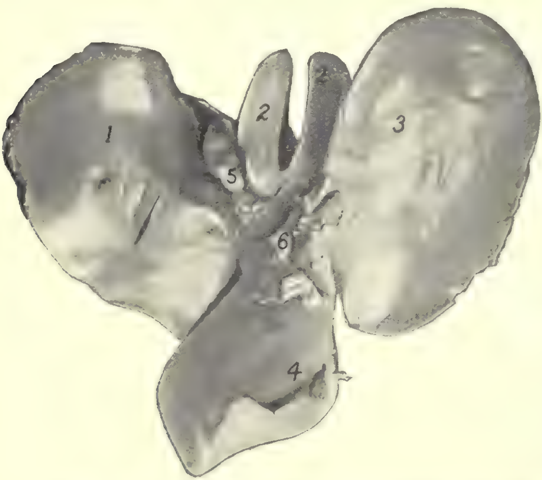


Fig. 16.—Liver of cat with lobes extended, viewed from the front. 1, the right lobe. 2, the two central lobes. 3, the left lobe. 4, the caudate lobe. 5, the gall bladder for storing the bile. 6, the entrance of the portal vein which carries the products of the digested foodstuffs to the liver.

The organ discharges three important functions. (1) It stores temporarily the sugar that comes from the food, and pays it out to the blood as required. (2) It manufactures **urea** out of materials which are derived from the tissues, especially from muscle. This may be called its urea-forming function. The urea is then given to the blood, and as it is dead waste, or material that is of no further use in the body, it is removed by the kidneys. (3) The liver secretes bile out of materials brought to it by the blood. This bile is stored temporarily in the gall bladder, and discharged into the duodenum every time that chyme is passed out of the stomach. The bile assists the pancreatic juice in the work of digestion, prevents the decay of the food, and promotes the regular action of the bowels.

Care of the Liver.

1. The liver is greatly injured by the continued use of alcohol. This organ purifies the blood which comes from the alimentary tract; but, under the continued irritation of alcohol, the liver gradually becomes less able to perform its work.

2. Avoid the continual use of purgative medicines. They may be taken occasionally for the temporary relief of constipation, but their systematic use does more harm than good. Constipation and diarrhœa are frequently due to errors in diet, and should be treated by a course of dieting.

LESSON XIII.

MESENTERY.

The large and the small intestines have attached along their length a thin sheet of connective tissue. This is known as the mesentery. One of its uses is to support the intestine and to attach it to the back part of the abdominal cavity. Another of its uses is to carry the arteries and veins which supply blood to the walls of the intestines.

The path of the blood-vessels is well shown in the accompanying figure by the dark lines in the large white bands. These bands are stores of fat, the fat being stored along the sides of the blood-vessels, so that it can be drawn upon if necessary during a period of starvation.

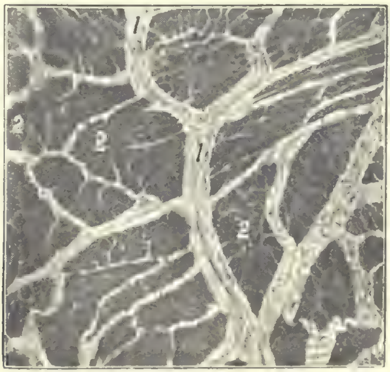


Fig. 17.—Portion of the mesentery. 1, 1, blood-vessel along the centre of a white band of fat. The fine white lines in 2, 2, 2, are lymphatic vessels. These carry some of the products of digestion, especially the fats, to a large lymphatic vessel, the thoracic duct, which in turn conveys the material up to the top of the thorax where it is emptied into a large vein.

The numerous fine, delicate white lines which lie in the interspaces of the broader bands of fat are **lacteal** vessels. These gather up the fat that has been absorbed into the intestinal walls from the food, and gather up also the liquid overflow of blood, the **lymph,** that has oozed through the walls of the blood capillaries in the mesentery, and transmits both fat and lymph through a large tube, the **thoracic duct,** upwards to be poured into a blood-vessel near the base of the neck.

From the foregoing it will be seen that, after the food has been absorbed into the intestinal walls, two paths lie open to it by which it can enter the system ; namely (1) by the blood-vessels along the mesentery, or (2) by the lacteal or lymphatic vessels of the mesentery. The peptones, sugar, salts and water enter by way of the blood-vessels of the mesentery, and are carried to the liver by the portal vein. The fats pass into the lymphatic vessels and are conveyed by the thoracic duct upwards to be ultimately poured into the blood stream. It thus happens that, no matter by which path the digested foodstuffs leave the intestine, in the end they reach the blood, and by it are carried throughout the body and used in nourishing the tissues.

The Regulation of Digestion.

The digestive apparatus is under the control of that part of the nervous system which is known as the **sympathetic** division of the **nervous system.** This part is located in the thorax and abdomen, on each side of the spinal column. It sends many nerve fibres to the lungs, heart, blood-vessels, stomach and intestines, and controls the whole of intestinal movement and intestinal digestion. It is a self-acting mechanism.

Care of the Digestive Organs.

1. Beyond being able to regulate the kind and quantity of our food, the hours at which we shall take meals, and the act of mastication, we can exercise no conscious control over the digestive processes.

2. Now, while it is quite true that we cannot control digestion, it is also true that we can do many things that will either hinder or promote this process. The selection of digestible food, its proper cooking, and the manner in which we eat it, will all influence, to a very great extent, the health of the digestive organs and the efficiency of their working. One of the commonest faults is over-eating, and this is largely due to lack of control of our sense of taste in eating sweets, pastry and many savory articles. There is little danger of over-eating, if food is plain.

LESSON XIV.

The Blood.

Material: a tumbler of freshly shed blood obtained from a butcher and allowed to stand. White strings of fibrin obtained by stirring fresh blood.

The blood is the great carrier of waste and repair. It carries the nutritive material derived from the food to every part of the body; and it gathers up, from every part, the material that is no longer of any use in the body, and carries this dead waste to the skin, lungs, intestines and kidneys. It is the function of these organs to thrust the waste material out of the system.

The blood is kept moving in tubes which run throughout the body, and this circulation of the blood goes on as long as life lasts. At every contraction of the heart muscle, about three and a half ounces of blood are forced out of the heart and into a large blood-vessel known as the **aorta.** This blood-vessel divides and redivides into smaller vessels called arteries, and by means of these the blood is distributed to all the different parts of the body. Then the blood is all gathered up again in vessels, called veins, and brought back to the heart.

While the contraction of the heart is the main force in the circulation of the blood, it is assisted in this work by the act of breathing and by the contraction of muscles all over the body. Vigorous exercise, therefore, improves the circulation of the blood, whereas idleness and inactivity promote sluggishness of the circulation. It is not hard to see that sluggishness in blood circulation will result in less nutritive material being carried to the tissues, and will result also in more of the dead waste being allowed to accumulate in the body, leading in time to impaired health and strength.

Clotting of Blood.

Nature takes care to prevent the loss of blood, as far as possible, when any of the smaller blood-vessels are cut. When this happens, the blood that is shed soon starts to **clot,** and the clot stops the flow of blood from the injured vessels. It is important, therefore, to know what to do in order to help blood to clot. Perhaps the best thing to do, if no large vessel is cut, is to apply hot water to the injured part. The water should be as hot as can be borne. The heat makes the small vessels

shrink in diameter, and this, along with the clot which forms, soon stops the bleeding.

If the blood-vessel which is bleeding be a large one, it should be compressed by placing a firm pad of cotton upon the path of the vessel, and then compressing this pad with a bandage tight enough to stop the bleeding.

After blood has clotted in a tumbler it may be turned upside down, and the clotted blood will still remain in the tumbler. If this clot be removed from the glass and washed and squeezed in a stream of running water, a small quantity of stringy, white fibrin will remain. This fibrin is the cause of the clotting, and may be obtained in larger quantity by stirring a pail of freshly-drawn blood with the hand, or with a bundle of twigs.

LESSON XV.

The Circulation.

It has been already stated that the contraction of the heart is the chief force in producing the onward movement of the blood.

The human heart is about the size of one's fist It is composed chiefly of muscle tissue. It contains four chambers, the two upper ones being known as the **auricles**, and the two lower ones, **ventricles.** We distinguish these cavities by speaking of them as the right and left auricles, and right and left ventricles.

The blood which has been gathered up from the head, trunk and extremities, is first poured into the right auricle. From here it passes into the right ventricle

through an opening that is guarded by a valve. This **tri-cuspid** valve, as it is called, allows the blood to flow from the right auricle into the right ventricle, but prevents the blood from returning. From the right

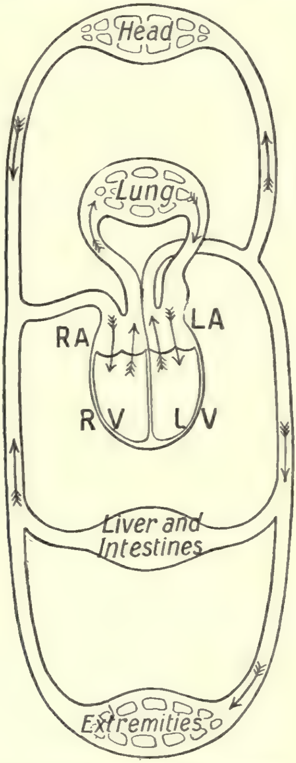


Fig. 18.—Diagram to illustrate the pulmonary and systemic circulation. The arrows show the course which the blood takes. RA, right auricle; RV, right ventricle; LA, left auricle; LV, left ventricle. The tricuspid and the mitral valves are indicated in this figure, but not the semi-lunar valves. For these latter see Fig. 31.

ventricle, the blood passes by the pulmonary artery to the two lungs where it gives up carbon-dioxide and gets oxygen. From the lungs, the blood is gathered up by the pulmonary veins and conveyed to the left auricle. From here it passes into the left ventricle through an opening guarded by the **mitral** valve, and from the left ventricle it is forced into the aorta. The aorta and the arteries, which branch from it, distribute the blood to the head, trunk and extremities, whence it is again gathered up by the veins.

The circulation of the blood through the lungs is known as the **shorter** or **pulmonic** circulation; the circulation throughout the body is the **longer** or **systemic** circulation (see Fig. 18).

Outward Signs of the Circulation.

Certain outward signs of the circulation had been known from the earliest times; but, it was not until Harvey had demonstrated the circulation that those signs were fully understood by physicians and surgeons.

Experiments.

1. Count the heart beats. The beat is best felt an inch below the left nipple and about an inch towards the middle line of the chest.

2. Count the pulse beats at the wrist, on the cheek just in front of the ear, or on the side of the neck close to the windpipe. Are the pulse beats per minute the same as the heart beats?

3. Let one arm hang freely by the side. Hold the other one straight up. Now note differences in (*a*) the color, (*b*) fulness of veins, (*c*) temperature of the hands.

4. Bare the front of the wrist. Note the pale blue colored veins. Press on one of these with the forefinger, sliding it first towards the palm of the hand and then towards the elbow. What change do you note in the vein in each case?

5. Press one finger tip on the skin at any part of the body where the skin is pink. What change in color do you note? Compare the effect in this case with similar pressure upon the finger nails.

These experiments are the outward signs of the circulation of the blood, but do not prove that the blood circulates. The circulation is now-a-days best demonstrated by watching the blood-cells move onward in the blood-vessels of a frog's foot, or in its mesentery, in the tail of a young tadpole, or in the body of a young fish immediately after it has hatched out of the egg. A microscope is necessary for these observations.

LESSON XVI.

Blood Vessels.

The arteries have many pulses along their course; when cut, the blood in them flows in jets; when tied, they swell up on the side next the heart; when empty, their walls do not collapse; the larger ones have walls composed chiefly of connective tissue, as they must be strong enough to sustain the pressure of the blood inside; the smaller ones have walls composed chiefly of muscle tissue, the fibres running circularly in the walls, so that the bore or calibre may be narrowed or widened and thus allow more blood or less blood to pass to various

organs, as may be needed for their work. The velocity of the blood-flow in the carotid artery in the neck of a man is from 300 to 500 mm. (12 to 19 inches) per second.

VEINS.

The veins have normally no pulse; when cut, the blood wells out; when tied, they swell up on the side away from the heart; their walls also are composed of muscle and connective tissue, but are thinner, weaker, and less elastic than those of the arteries, and hence collapse when empty. They serve mainly as channels for conveying the blood back to the heart, and possess valves here and there along the surface of their inner coat. Diagram 19 represents the appearance of a valve in a vein.

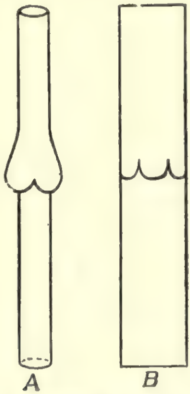


Fig. 19.—Diagrammatic Portion of a vein to show the valves. *A*, vein unopened, the enlargement represents the accumulation of blood just past the valve. *B*, vein opened and spread out flat. One valve is uncut; its fellow has been split lengthwise in opening the vein.

The velocity of the blood-flow in veins is about half of that in the corresponding arteries.

CAPILLARIES.

The united sectional area of the capillaries is several hundreds of times greater than that of the aorta. Consequently the blood stream is much slower in the capillaries than in the arteries or veins—about ¾ mm. per second in a mammal. This slow rate of flow allows time for the nutritive material in the blood and for the oxygen to pass out of the capillaries into the lymph, and thence to the tissues.

CARE OF THE CIRCULATORY ORGANS.

1. Blood-vessels feel the strain of athletic training as well as the heart. Veins rupture and become varicose as a result of the extra blood pressure.

2. If a large artery or vein in a limb is cut, the rapid flow of blood prevents clotting. Under these circumstances, the limb should at once be grasped firmly with the hands and pressure applied above the wound if it is an artery, below the wound if it is a vein. Then a strong handkerchief, or half-inch cord, should be tied loosely round the limb and a stick run below the bandage and turned so as to bring great pressure to bear upon the bleeding vessels. This will stop the most profuse hæmorrhage in any limb. A physician should then be summoned.

3. If the wound has been made with a dirty knife, tin can, or glass, it should be thoroughly washed with water that has been boiled. The water should be as hot as can be borne, and should contain some antiseptic. Soil and air are filled with minute bodies, known as bacteria, and these getting into wounds set up suppuration and sometimes blood-poisoning.

LESSON XVII.

Waste.

Every hour we live, very small particles of our body are wasting away. We have to take food in order to make good this waste. But something more is needed besides taking food. The waste matter must be removed from the body. If it were not removed it would soon accumulate in the body and poison the flesh and blood and bring life to an end. The removal of this dead waste from the body is known as **excretion.**

Now there are four main avenues by which waste matters are thrust out of the body. Some waste passes out by the skin in the form of sweat; more passes out from the lungs in expired air, and more still passes out by the kidneys. The alimentary canal is another avenue by which waste is removed. In order to maintain health at its best, these four organs must be kept in a healthy condition. We cannot exercise any conscious control over the working of these excretory organs, but we can aid them vastly by observing the general rules of health. If we follow these rules we need not worry about the work of the sweat glands, lungs, intestines or kidneys.

It has already been stated that the blood is the great carrier of waste and repair. From all the tissues of the body—muscle, nerve, tendons, bones, etc., this waste is gathered up by the blood and carried to the principal organs of excretion, and these organs remove the waste from the blood and thrust it out of the body.

A number of substances found in bile are waste material from blood corpuscles and from nerve. Examples of

these are the bile pigments, or coloring matter of the bile, and cholesterin which sometimes forms gall stones in the gall bladder. When we are "bilious," the bile has ceased to come away freely from the liver, the cause being usually lack of exercise in the open air, or indiscretions in diet.

Rules for Removal of Waste.

1. Plenty of exercise is essential for the removal of waste, because exercise promotes the circulation of the blood and thus tends to carry out the waste materials from the tissues to the several organs of excretion.

2. Massage should be substituted for exercise in the case of people who are too delicate or too frail to take adequate exercise for themselves.

3. In order to secure efficient removal of waste, an adult should drink about a quart of water per day, preferably between meals. If he drinks tea, coffee, or other liquid, he will need just that much less water.

4. When waste has accumulated in the tissues, as in rheumatism, or gout, copious draughts of mineral waters, under medical supervision, sometimes give great relief; because the water dissolves out the waste material and enables the blood to carry it to the organs of excretion.

LESSON XVIII.

Body Heat.

Material: a physician's thermometer. If this is not available, use a chemical thermometer.

The temperature[1] of the body should be taken from a number of pupils. To do this, the bulb of a physician's thermometer should be placed under the tongue, and the lips should be closed.[2] The thermometer should remain in the mouth for four or five minutes, so as to ensure that the instrument has become of the same temperature as the closed mouth. The temperature should then be read off and recorded on the blackboard.

A chemical thermometer may be used, but it will not give such accurate results. Another location from which the body temperature is sometimes obtained is the armpit. The chief precaution to be observed in getting the body temperature is to see that the instrument is not exposed to a draught of air. The temperature of the body varies in health between 97.3° F. and 98.9° F.

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[1] Before teaching this lesson, the teacher should have gone over the subject of Heat, Form III, page 58 of the new regulations.

[2] On removing the thermometer, hold the instrument horizontally with the white or milky side turned away from the observer, and the bulb towards the left hand. Then look along the stem of the instrument towards the right until the mercury shews clearly against the white back-ground. Read off the degrees in whole numbers and in tenths. After this has been done, hold the instrument firmly in the right hand, and strike the right hand (not the instrument) against the left. This sends the mercury down the stem again towards the bulb, and the instrument is "set." After washing in water, it is ready for another observation.

The nervous system regulates the production and loss of heat so nicely that the body hardly ever varies more than one or two tenths of a degree from the above figures. When the body tends to become cold, the production of heat is increased chiefly by the muscles and glands, and the loss of heat from the surface is lessened by the blood being driven from the skin to the inner parts of the body. On the contrary, when the body tends to become too hot, the generation of heat by muscles, glands, etc., is lessened, and the loss of heat is increased by the blood being sent to the skin where the heat is lost by conduction, convection, radiation, and by the evaporation of the sweat. This regulation of body temperature may be perhaps better understood by asking the pupils to consider what we do in our houses in winter.

If a room becomes too cold, we put more fuel into the furnace and open the draughts; that is, we increase the production of heat. In addition to this, we stop up cracks around doors and windows, so as to prevent the loss of heat from the room. These two steps tend to increase the temperature of a room or house.

On the other hand, if a room is too warm, we close the dampers and cease putting fuel into the furnace. This lessens the production of heat. But in addition to this, we may open doors or windows and allow the hot air to escape, and thus reduce the temperature of the room. In a somewhat similar way, the body temperature is regulated, but in so exact a manner that the variations from the normal are very slight.

Fever is the condition in which the body temperature rises above 98.4° F. This occurs whenever any serious

injury is done to the body, or whenever bacteria or disease germs get into the system and multiply in the tissues, blood, or lymph.

On the other hand, in starvation or in prolonged exposure to cold without adequate clothing, the body temperature falls below the normal. Drinking alcohol causes a lowering of the temperature, although many people are under the impression that it makes them warm.

LESSON XIX.

Exercise.

Why should children take exercise? Do adults require exercise? If so, do adults require exercise for the same reason that children do? These questions will probably develop the answer that children require exercise of body for growth of body, and exercise of mind for growth of mind. Exercise in moral acts for growth in moral acts is quite as essential as the other two, but this conception is probably quite beyond young children.

Further questioning as to the best forms of exercise would probably elicit the fact that some children get little or no exercise in the shape of play or calisthenics, but do get the exercise necessary for growth by working on the farm, or at some other form of manual labor.

Exercise, besides being essential for growth, is equally essential for health when growth has ceased. Lack of exercise results in lowered heart and lung action,

reduced temperature, and the accumulation of waste in the tissues. The amount of exercise necessary to maintain the body in a healthy condition varies very much in different people.

Rules for Exercise.

1. We should exercise as far as possible all the muscles of the body, especially those which appear to be weak.

2. The best of all exercises is out-of-door games.

3. Next to these, the best exercise is brisk walking or running. Girls, as well as boys, should learn to swim. In addition to cleaning the skin, swimming is an excellent exercise.

4. Properly chosen calisthenic exercises and gymnastics are beneficial for growth and recreation. In cities and towns, in which playgrounds are lacking or small, calisthenic exercises are absolutely essential for the health of children. A symmetrical development of all of the muscles will produce a beautiful form of the body.

5. Exercise should never be carried on until the body becomes thoroughly fatigued. It should stop after a reasonable time, and while one feels that he could enjoy more of it.

LESSON XX.

Drinking Water.

Where do we get our drinking water[1]? City children will answer that we get it from taps; children in small villages and in country places will say that it comes from wells, springs, creeks, rivers or lakes. Which of these is the best source of supply? This question will show that rural children are naturally firm believers in the good qualities of the home supply of water. The study of the water supply of a school section should be related to the geography lessons on the locality. Can we expect pure water from a creek which passes farmers' barns and outbuildings? Or from a river along whose banks there are villages which discharge their drainage into the stream? Would a well near a stable or barnyard be a good source from which to get water? A city is situated on a bay and discharges its sewerage along the water front; would the bay be a fit source from which to get water for the citizens?

Water from a deep spring and away from sources of contamination probably furnishes the purest kind of drinking water. Large lakes are also likely to furnish good water. But it must always be remembered that we can never tell by looking at water, or even tasting it, whether it is wholesome or not. Clear-looking water may contain the germs of disease; on the other hand, dirty-looking water may be quite harmless. Some

[1] Before teaching this lesson, the teacher should have gone over that part of Nature Study for Form III, which treats of natural waters. See page 58 of the new regulations.

impurities are harmless, and some are very injurious. The most dangerous impurities in drinking water are minute living plants, called **bacteria.** Typhoid fever has often been disseminated over a large district through the agency of drinking water that has been contaminated with typhoid bacteria.

Rules.

1. A well should always be located at a considerable distance from a barnyard, privy, or any other source of contamination.

2. Wells should generally be sunk on high ground.

3. Water which contains the germs of disease may be rendered harmless by boiling it for half-an-hour. If typhoid fever is prevalent in a city or town in which there is a water-works system, it is a wise precaution to first boil the water and then cool it before drinking it.

LESSON XXI.

Dirty Milk.

Milk is pure and fresh as it comes from a healthy cow, sheep, or goat. It is described as **adulterated** when mixed with water, chalk, or other adulterants. It is **skimmed**, when the cream has been removed from it. It becomes **impure**, when skimmed, watered, or "doctored," or when dirt is allowed to mingle with it from any source. Dirt may get into milk from various sources, especially when cows are kept in stables. Cow stables are usually dirty: their atmosphere dusty. The animals have frequently to lie down in their own filth.

This sticks to their hair, and, later on, dries and drops off into the milking pail. Too many milkers wear dirty clothes, have dirty hands, and use dirty pails, dirty strainers and dirty cans.

Now, dirty milk is always dangerous. It is dangerous because it sometimes contains the germs of typhoid fever, scarlet fever, and diphtheria, and is then a means of spreading these diseases in cities and towns. One milk seller has been known to spread scarlet fever over a large part of a town.

The only way in which milk can be made safe for drinking is to boil it, or pasteurize it, especially if it has to be kept for some time. Pure, fresh milk is pasteurized by placing it in a thoroughly clean vessel, and keeping it for at least twenty minutes or half an hour at a temperature of 160° F. It should then be cooled, covered, and kept on ice until it is used. Milk for babies and invalids should be obtained fresh from the cow every morning and evening.

LESSON XXII.

THE VOICE.

Material: larynx of a sheep or an ox obtained from a butcher.

The sounds which we call voice are formed in a kind of box in the front part of the neck. This organ can easily be felt from the outside. The proper name for it is the larynx. It is the expanded upper end of the windpipe, and is made of four pieces of gristle or cartilage. Stretching from front to back of this cartilaginous box

are two folds of whitish flesh, called the vocal cords. The air, in passing out from our lungs, makes these folds of flesh swing up and down, just as do the little tongues of brass in a mouth organ. In thus moving up and down, they make the sound which we call voice.

Care of the Voice.

1. Singing too loud or too high will strain the voice and make it harsh.

2. We should sing very little, when we have a cold.

3. Well-bred people never talk in loud harsh tones; because this habit will spoil the voice and render it very unpleasant. A low distinct voice can be heard as far as a loud harsh one.

4. Children should learn to speak in a natural, pleasant voice.

LESSON XXIII.

Stimulants, Sedatives, and Narcotics.

A **stimulant** is a medicine or drug which, when taken into the body, excites or stimulates the brain and nerves. This excitement or exhilaration is pleasant to many people, and so they are led to take more of such a drug or medicine. When under the influence of a stimulant, like alcohol, people imagine they can do more work or better work than under ordinary circumstances. They think they can run faster, or jump higher, or lift a heavier weight, or compose more skilfully, or count more quickly with the help of the stimulant than without it.

But the facts all go to show that the very opposite is true. Tea and coffee are mild stimulants, and ultimately their excessive use brings on indigestion in many people.

A **sedative** is a drug or medicine which produces the opposite effect to that of a stimulant. It depresses the brain and nerves; that is, it deadens them to some extent, so that neither brain nor nerves are able to feel or act as they should. **Narcotics** act more powerfully than sedatives. They benumb the nervous system, and, in large doses, they put people into a deep sleep that is known as **narcosis.**

But, in reality, no sharp distinction can be drawn between stimulants, sedatives, and narcotics. The same drug, when taken in different quantities, may act as either stimulant, sedative, or narcotic. For example, in small doses, alcohol and opium are stimulants; but when the doses are increased, both these drugs will produce sedative effects and, ultimately, narcosis.

Alcohol is found in different quantities in many kinds of drinks. There is from five to ten per cent. of alcohol in cider. In beer, there are from four to six parts of alcohol in every one hundred parts of the liquor. In wines, the quantity of alcohol varies from eight or ten up to seventeen parts per hundred. Whiskey contains from thirty to fifty parts of alcohol in every one hundred of the liquor, and consequently produces intoxication much more quickly than does beer or wine. The only safe rule to follow is to abstain totally from the use of alcohol in any form whatever.

The great danger in using either stimulants or narcotics is that of acquiring an appetite for them, so

that their use cannot be controlled. The alcohol or opium habit soon renders a man utterly unfit for filling any responsible position. This is so well-known now-a-days that many railroad, manufacturing and mercantile companies not merely decline to employ drunken men, but dismiss those already in their employment who are discovered to be addicted to the alcohol habit.

LESSON XXIV.

Effects of Tobacco.

Material: Package of cigarettes; 1%, 2%, and 5% infusions in water. Watch glasses. Small aquatic animals of different kinds.

A very interesting demonstration of the poisonous effects of tobacco may be given by making infusions of cigarettes in water. One cigarette should be soaked over-night in about 3½ fluid ounces of water. This will give what may be called a one per cent. infusion. Two cigarettes in this same volume of water will give, of course, a solution of twice the strength; and five cigarettes in this quantity of water will give a five per cent. strength of tobacco solution.

The general method of studying the poisonous effects of tobacco is to procure small aquatic animals, immerse them in these different solutions in watch glasses and observe the effects. If the animals are very small, it will be necessary to use a magnifying glass or a compound microscope with which to watch their movements.

Some vorticellæ, paramœcia and gammari were immersed in the one per cent. infusion for five hours

and then examined. The vorticellæ were all dead; the paramœcia appeared to be perfectly normal; the gammari were almost motionless, the heart and circulation being considerably slowed. On transferring the gammari to fresh water they all revived.

In another experiment the paramœcia and gammari lived for sixteen hours in a one per cent. solution without being killed by it.

Another batch of these same animals were placed in a two per cent. infusion for sixteen hours. On examination, both the vorticellæ and paramœcia were found to be dead; the gammari were still living but very stupid.

The first effect of a five per cent. infusion upon those animals was to greatly increase their movements. Soon, however, the sedative action of the poisonous solution showed itself. In twelve minutes the vorticellæ were all dead; in seven minutes the paramœcia were also. The first effect upon the gammari was to increase bodily movement, heart beat and circulation of the blood, but this lasted for a few minutes only, and in fifteen minutes all movement had ceased.

Some microscopic nematode worms, which are usually to be found in decaying matter in water, lived over-night in a five per cent. infusion, but their movements were so greatly reduced as to give the impression that they were dead. Although they were returned to fresh water, they never recovered their normal activity.

These experiments are sufficient to demonstrate that tobacco acts first as a stimulant and then as a sedative and narcotic.

LESSON XXV.

Stimulants and Narcotics.

Apart from personal testimony which will always be conflicting, and apart from scientific experiments, the most of which have been opposed to indulgence in alcohol, the evidence against its use is furnished from armies, from hospitals, from large public works, and from life insurance companies.

The practice of distributing alcohol to United States soldiers was discontinued in 1862, because it was found that their health, spirits, and endurance of fatigue, were all increased by abstinence from liquor rations. Precisely similar results followed the discontinuance of the use of alcohol among the British soldiers who took part in the expedition up the Nile, and in the Boer campaigns. Contractors who employ large numbers of men upon public works also claim that workmen who are total abstainers can do more work than those who take liquor even in very moderate quantity.

In hospital practice, one of the first questions which the physician asks a patient, if he is suffering from a serious disease, is whether he is a total abstainer or not. The man who has abstained from the use of alcoholic liquors has a chance of recovery, when the regular drinker has little or none. Statistics go to show, too, that half the patients who suffer from insanity have contracted the disease, either directly through the effects of alcohol, or indirectly through the weakened nervous organization which has been inherited from drinking parents.

Lastly, the statistics of life insurance companies—notably the English ones—go to show that total abstainers live longer than those who are in the habit of using alcohol.

Tobacco is one of the milder narcotics. It is now rarely used in medicine on account of its well-known poisonous properties. The poison present in tobacco is nicotine. Haberman gives the following quantities as existing in cigars. In the cut-off end 3·6%; in the unsmoked ends 36%; in the part smoked 60%, of which 16% is drawn into the mouth in smoking.

Nicotine is a powerful depressant of the heart's action. Those who smoke tobacco to excess frequently have "tobacco heart;" that is, weak and irregular heart beat. At first, tobacco smoking causes nausea and vomiting, but this effect soon passes off, and the habit for some years, perhaps, appears to cause no ill-effects. But in time it produces in some people indigestion, and in others diffused granular irritation about the pharynx, known as "smokers' sore throat." Smoking is more injurious before the twenty-fifth year of age than after that period.

Moreover, in the case of the young, it is believed to check the healthy growth and development of the body. It temporarily lowers one's muscular power, and consequently athletes in training are forbidden its use. Cigarette smoking, especially if the smoke is drawn into the lungs, is more harmful than ordinary smoking, and no boy can practise this habit very long without lowering his bodily vitality and mental vigor. Some employers of labor know this fact very well and refuse to engage young men who smoke cigarettes.

Tobacco chewing is too disgusting to necessitate discussion.

It is a good rule to avoid taking any kind of medicine, whether stimulant, narcotic, purgative or tonic, excepting when prescribed by a regular physician. Many of the patent medicines so widely advertised and extensively used by the public are absolutely worthless, when not positively harmful.

LESSON XXVI.

Poisons.

A poison may be defined as any substance that destroys life or seriously injures the health. Webster's dictionary defines it as "any agent which, when introduced into the animal organism, is capable of producing a morbid, noxious, or deadly effect upon it." This definition will include a large number of substances not usually considered poisonous; but the fact is that it is difficult to define a poison. The effect of many substances upon the human body depends upon the quantity or dose that is administered. In very small doses and for a short time, morphine is not poisonous; nor is strychnine, but in larger doses they both are.

When common household poisons such as paris green, fly poisons, corrosive sublimate (a disinfectant), paregoric, soothing syrup, ends of matches, are taken by accident, the first thing to do is to send for a physician. While awaiting his arrival, however, it is generally advisable to

induce vomiting. This may be done by giving a teaspoonful of mustard in a glass of warm water. Repeat the dose in about ten minutes if the first produces no effect.

The following antidotes may be given after the emetic to counteract the effects of any of the poison which may remain in the body :—

1. For acid poisons, such as nitric, sulphuric, carbolic, or muriatic acids, give at once, without producing vomiting, three or four spoonfuls of soda, baking soda, or a glass or two of limewater.

2. For any kind of lead poisoning (sugar of lead, or white lead), give a large dose of Epsom salts or Glauber's salts.

3. For corrosive sublimate or verdigris, give white of eggs, or flour and water.

4. For opium poisoning (paregoric, soothing syrup, laudanum), keep the patient walking about and give frequent drinks of strong coffee.

5. For strychnia poisoning, administer ether or chloroform to relieve the muscular spasms. If the respiration stops, keep up artificial respiration.

6. In arsenic poisoning (paris green or fly poisons), mix tincture of iron with baking soda, and give the patient every minute or two a teaspoonful of the brownish powder that forms

7. For poisoning with matches, give white of eggs, or powdered charcoal.

What Eminent Authorities Say.

"Smoking prevents the healthy nutrition of the several structures of the body ; hence comes, especially in young persons, an arrest of growth of the body ; low stature, a pallid and sallow hue of the surface, an unhealthy supply of the blood, and weak bodily powers."—JAMES COPELAND, M.D., F.R.S., *Editor of London Medical Repository*.

"ALCOHOL.—Small quantities of the alcohol taken leave the body by the breath and urine as such, the greater amount is decomposed into simpler products (acetic, oxalic, carbonic acids, and water); the formation of these must give rise to a certain amount of bodily heat. It has been calculated that a man can burn off in his body two ounces of absolute alcohol daily. Alcohol is thus, within narrow limits, a food. It, however, lessens proteid metabolism by about six per cent., and thus ultimately leads to a diminution of the heat produced in the body. It is, moreover, a very uneconomical food; much more nutriment would have been obtainable from the barley or the grapes from which it was made. The value of alcohol used within moderate limits is not as a food, but as a stimulant not only to digestion, but to the heart and brain."—PROFESSOR HALLIBURTON, *King's College, London, Text-Book of Chemical Physiology and Pathology.*

"With regard to *alcohol*, its exact influence, when taken in moderation by those who use it as an article of diet, cannot be precisely stated. It has been asserted by several observers that alcohol is eliminated from the body as alcohol by the various excretory channels. The evidence of this is doubtful, and it is probable that it is split up into simpler compounds. . . . A small part of the alcohol ingested no doubt is exhaled by the mucous membrane of the lungs and by the kidneys. The odor of the breath depends on the elimination of oxidation products, such as fusel oil. If oxidized even to a small extent, and the evidence, as already indicated, points to the oxidation of by far the larger proportion of it (95 per cent), alcohol must be regarded, in the scientific sense, as a food. No doubt also its ingestion diminishes the metabolism of proteids to the extent of about six per cent., as shown by the diminished excretion of urea. Its oxidation will also be attended by the production of heat; but as, on the other hand, it lessens the production of heat by interfering with the metabolism in proteid tissues, and also by diminishing the oxidation of carbohydrates and fats, the final result is an actual diminution of bodily temperature. While, therefore, alcohol must be classed technically as a food, it is in many respects an unsuitable food, and its place can be taken with great advantage by other substances. In small

doses it acts as a local excitant of the digestive mucous membrane, and afterwards as a diffusible stimulant upon the circulation and central nervous system. In some cases it may aid the digestive process; but in a state of health it is not only not required, but its use, except in small doses, is positively prejudicial."—PROFESSOR M'KENDRICK, *Glasgow University*, *Text-Book of Physiology.*

"It matters not that alcohol is oxidized in the body with the liberation of energy. So also are several of the organic poisons, as for instance, muscarine, the active principal of the poisonous mushrooms. Yet no one thinks of classing these substances as foods."

"Alcohol has a poisonous action, and since this action is exerted in such a way as to make the sum total of its effects harmful whenever enough is taken to prove a practical factor in energy production, alcohol should not be classed with the foods."—HENRY F. HEWES, A.B., M.D., *Teacher in Physiological and Clinical Chemistry*, *Harvard Medical School.*

PART IV.

LESSON I.

THE SKELETON.

All the outer parts of the body are soft and pliable; but within the yielding flesh, we can always feel the solid bones which support the pliable parts. This whole framework of bone is known as the **skeleton.** Fig. 20 is from a photograph of a human skeleton. It shows that the principal parts of the body are determined by the skeleton. Thus, the bony part of the head is the **skull**; the bony part of the trunk includes the **backbone, ribs, breast bone, shoulder bones** and **hip bones.** The bones of the arm are the **humerus, radius** and **ulna,** eight **carpal** (or wrist bones), five **meta-carpal,** and fourteen finger bones or **phalanges.** The bones of a lower limb named in order downwards are the **femur, patella,** or knee cap, the **tibia** and **fibula,** seven **tarsal** (or ankle bones), five **meta-tarsal,** and fourteen **phalanges,** or toe bones.[1]

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[1] The teacher should make certain that the pupils can identify the five meta-carpal, or hand bones; the fourteen finger bones; the five meta-tarsal, or foot bones; and the fourteen toe bones. The meta-carpal and meta-tarsal bones can be felt through the flesh by applying the tips of the fingers firmly to the hand in the one case, and to the foot in the other.

The skull may be said to consist of two parts, the upper part, or **cranium**, and the face. The cranium

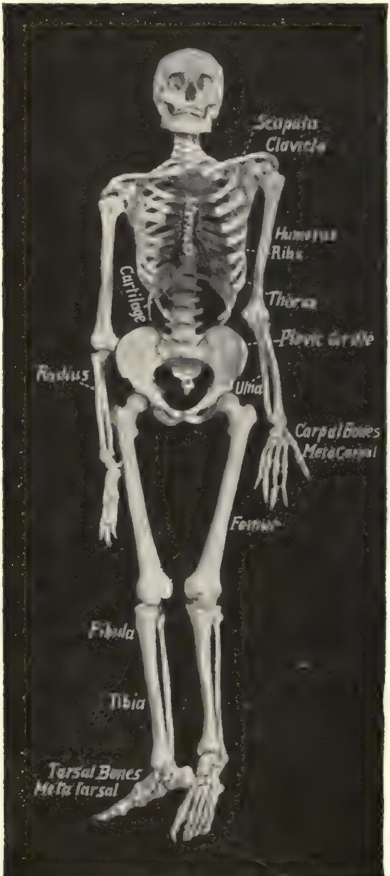

Fig. 20.—The human skeleton.

contains the fore-brain, hind-brain, and the enlarged upper end of the spinal cord, known as the medulla

oblongata. The rest of the spinal cord runs in a canal through the whole length of the backbone. The cranium or brain-box seems to be one solid bone, but in reality it is made up of eight separate pieces. Figs. 21 and 22

Fig. 21.—The skull bones, front view. All the bones have been separated from each other, that is, they have been disarticulated. The cheek bone, nasal bone, and upper jaw bone are easily recognized for each half of the face. Part of the upper and of the lower jaw bones has been cut away sufficiently to show the roots of the teeth.

show some of these bones separated at the front, side and back of the skull. Note how the edges of the bones are notched, so that, when in their natural

Fig. 22.—Skull bones, side view. The occipital bone forms the under and back part of the head ; the parietal bones form the sides and crown ; and the frontal bones form the forehead. The temporal bone contains the ear.

position, they form immovable joints for the better protection of the delicate brain within.

The face bones number fourteen; that is, seven on each side, and most of them are firmly jointed together so as to admit of no movement between the parts. The exception is the lower jaw bone, which is freely movable at its upper end, where it is jointed to one of the cranial bones. Movements of the lower jaw in mastication take place in three directions, namely, up and down, side to side, and forwards and backwards, and result in the food being thoroughly ground between the molar teeth.

The backbone forms the central support for the trunk. It is not a single piece, but consists of a series of thirty-three small bones, **vertebræ,** all bound snugly together and allowing of considerable freedom of motion between the separate parts. This is true of twenty-four of the pieces. Five of those near the lower end, however, are in grown-up people firmly united to the hip-bones. The remaining five form the tail bones.

Many other animals have backbones besides man. Fish, reptiles, birds, and mammals all possess a backbone, and hence these are known as **vertebrated** animals.

The skeleton of an adult consists of about 200 bones, that of a child contains more than 200. This is because some of the bones in childhood can be separated from each other; whereas in adult life, they have grown firmly together.

LESSON II.

JOINTS.

Materials: the shoulder joint of a lamb; the ankle of a fowl.

Joints occur at all points of the skeleton, where two or more bones are joined together. Some joints allow of no movement of the bones whatever, as in the

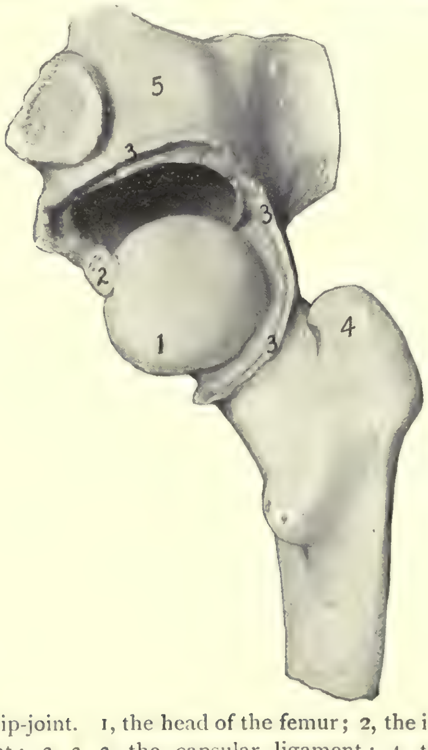

Fig. 23.—Hip-joint. 1, the head of the femur; 2, the inter-articular ligament; 3, 3, 3, the capsular ligament; 4, the great trochanter—an enlargement for the attachment of muscle; 5, the part of the hip-bone into the hollow of which the rounded head of the femur fits.

case of the joints of the cranium. Other joints allow a great amount of movement, as at the shoulder, or at the hip-joint. A third form of joint is one in which a small amount of movement is allowed, as in the joints between the bones of the spine.

The joint which allows of the greatest range of movement is the **ball-and-socket** joint, examples of which occur at the shoulder and the hip. In both these cases the rounded upper end of a long bone fits into a cup-shaped hollow or socket. A large ligament surrounds the **socket** and covers the **ball**-shaped end of the long bone. This ligament is therefore known as the capsular ligament.

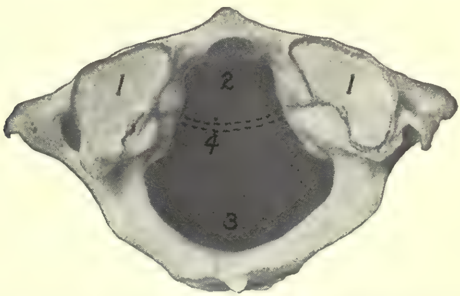

Fig. 24.—Atlas or top bone of the spine, viewed from above. 1, 1, the surfaces upon which the occipital bone of the skull rests ; 2, 3, the opening through the bone, sub-divided by a ligament (4) which crosses from one side to the other. The larger space (3) allows the spinal cord to come out from the brain. The smaller space (2) receives the odontoid process of the axis, the second bone of the spine.

The elbow and knee are known as **hinge** joints, because, in these, movement can take place in only two directions—forward and backward.

Gliding joints occur between the separate bones of the middle and upper part of the spine. There is a

gliding joint also where the lower jaw bone joins the skull. Lastly, we have a **pivot** joint between the two uppermost bones of the spine. The head rests upon the topmost bone of the spine by two surfaces which are shown in Fig. 24. This bone is known as the **atlas** bone, and the joint which it forms with the cranium allows the head to move forward and backward, as in nodding. When, however, we wish to turn the head round either to the right or left, the turning takes place between the atlas and the second bone of the spine, the **axis.** This bone bears upon its front and upper surface a tooth-like projection or pivot, which fits into an opening in the atlas above. This projection or pivot is known as the odontoid process, and it is round this pivot that both head and atlas turn.

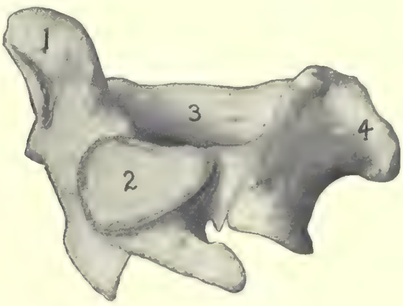

Fig. 25.—The axis bone viewed from the side. 1, the odontoid process which fits into the opening (2) of Fig. 24; 2, the surface which joins the atlas above; 3, the opening through which the spinal cord passes downwards along the spinal canal; 4, a short spine projecting backwards. Many of these spinous processes belonging to other vertebræ can easily be felt through the skin lower down along the back.

CARE OF JOINTS.

1. If a bone is forced out of its natural position in a joint, the bones are said to be **dislocated.** When bones are thus "put out of joint," the ligaments get broken and the bones must be put back again along the same course by which they came out. In simple dislocations of the fingers or wrist, the bones can generally be returned to their proper position by pulling on the joint and pressing the bones into their place.

2. A **sprain** is a tear or strain of the ligaments of a joint. A tear is much more serious than a strain. In the latter case, the joint should be bathed thoroughly in water as hot as can be borne for ten or fifteen minutes. This should be accompanied with brisk rubbing of the joint. Then the joint should be rested for some time, according to the extent of the injury. If the ligaments are torn, a physician or surgeon should be consulted.

LESSON III.

BLOOD AND LYMPH.

How is nutritive material carried all over the body so as to keep the tissues alive and enable them to continue their work, and how is the dead waste gathered up from every part of the body, carried to the surface and thrust out? These questions bring us to consider the general work of the blood.

The blood circulates in arteries, veins and capillaries. The arteries carry the blood from the heart all over the

body, branching and re-branching the farther they get away from the heart, and becoming smaller in diameter all the time, until finally they become a fine set of tubes known as the capillaries. These convey the blood through every organ and tissue of the body. The veins gather up the blood from the capillaries and return it to the heart again (see Fig. 26). The capillaries have very

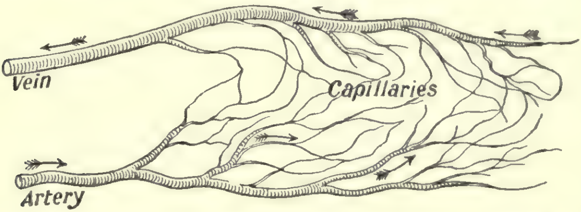

Fig. 26.—Diagram to illustrate how a small artery breaks up into smaller arteries, and these into capillaries. Also, how the capillaries unite to form small veins, and these again, larger veins. Every organ is supplied with blood by one or more arteries, and the blood is carried away from the organ by corresponding veins. The interspaces between the capillaries is filled with lymph.

thin walls—thinner than any tissue paper—and allow the liquid part of blood, and material dissolved in the liquid, to escape through their walls. The liquid which thus escapes through the capillary walls into the tissues and tissue spaces is known as lymph.

Blood is always found on the inside of blood-vessels; lymph is always found on the outside of blood-vessels and bathing the tissues. There is a stream of liquid nutritive material passing from the blood through the capillary walls into the lymph all the time, and from lymph into the tissues. This material is used up by the tissues for their nutrition. On the other hand, there is

a stream of waste material passing from the tissues into lymph, and from lymph back again into the blood. All lymph comes from the blood and is returned to the blood again, either directly through the capillary walls, or by lymphatic vessels. Lymph circulates through parts of the body where blood does not go. For example, we find no blood in the denser parts of bone, cartilage, or tendon, nor in nerve fibres or muscle fibres (see Fig. 27). The nutrition of these tissues is carried on by the lymph.

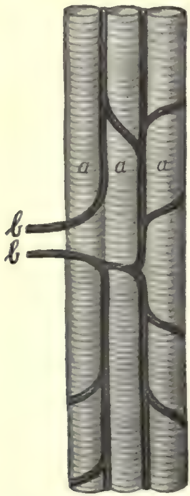

Fig. 27.—Diagrammatic. Three muscle fibres *a, a, a,* with blood capillaries *b, b,* running between the fibres or partly surrounding them. Lymph exudes through the walls of the blood capillaries, bathes the muscle fibres and gives them the nutritive material which they require.

Blood does other important work. It takes oxygen from the air in the lungs and carries it to the tissues;

and it carries back from the tissues carbon dioxide and gives it up to the air in the lungs.

It can easily be seen from this consideration of the general work of blood that its composition must be varying all the time, and it is for this reason that it has not been possible to determine its exact chemical composition.

LESSON IV.

Blood Cells.

Fresh blood is composed of a pale, straw-colored liquid, the **plasma,** and, floating in this, a large number of rounded bodies, the blood **corpuscles,** or blood-**cells.** There are two kinds of these cells, red ones and white ones (see Figs. 28 and 29). A large quantity of blood

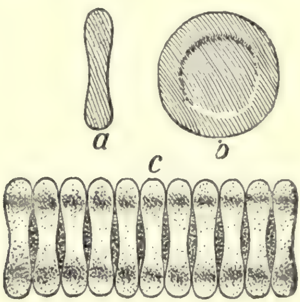

Fig. 28.—Red blood-cells are flattened bi-concave discs, something like a circular biscuit, but thin in the middle and thicker at the edges. *a*, a red cell seen edgewise. *b*, one seen on the flat. *c*, a collection of red cells which adhere to each other and form rouleaux.

is red in color, but when a thin layer of it is examined, even with the naked eye, it appears to lose its red color and to become straw-colored. There is only one white cell for every 400 or 500 red ones. White cells pass through the blood capillary walls, and are present in lymph; red ones are not.

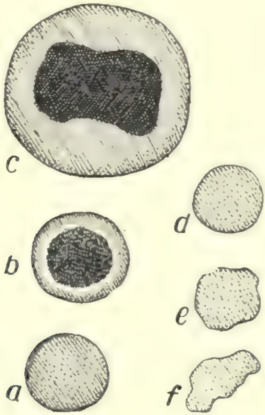

Fig. 29.—White blood-cells of different sizes and shapes. *a*, a small granular one. *b*, one showing the nucleus. *c*, a very large nucleated cell. *e*, *f*, white cells which are changing their shape. Figures 28 and 29 show the blood cells highly magnified.

The function of the red blood-cells is to carry oxygen from the lungs to the tissues. Tobacco impairs this function. The white cells and the plasma are the carriers of nutritive material.

Red cells increase in number through rest during the night, and decrease during the day. They increase by residence at high altitudes, as on a mountain; they decrease through the effect of bad air and lack of proper food.

Quantity and Distribution.

From $\frac{1}{10}$ to $\frac{1}{14}$ of the total weight of the body is blood. In starvation the blood lives upon the other tissues. The fat is the first to be used, but later on the glands and the muscles are all drawn upon in order to keep up a uniform quality of blood.

Its distribution in the body is roughly as follows:—
One quarter in the heart, lungs, and larger blood-vessels.
One quarter in the liver.
One quarter in the outside (skeletal) muscles.
One quarter in all other organs.

Care of the Circulation.

1. "Taking cold" is an affection of the skin that comes on from sudden or prolonged exposure to cold. The cold contracts the blood-vessels of the skin, and the blood becomes congested in the internal organs. If the congestion and resulting inflammation occur in the nose and throat, we are said to have a "cold in the head;" if they occur in the bronchial tubes, bronchitis results; if in the lungs, pneumonia; if in the lung covering, pleurisy. Such diseases, however, are really caused by specific bacteria. The cold is only the predisposing cause. If the cold affects the intestines the result is a temporary diarrhœa.

2. People should not, therefore, go from a hot room into the cold without putting on extra clothing.

3. In case of persistent bleeding, a person should lie down and remain perfectly quiet.

4. Fainting results from a lack of blood in the brain. When it occurs in a room, the patient should be placed in the horizontal position, the clothing should be loosened, and fresh air admitted.

LESSON V.

Internal Signs of the Circulation.

We cannot do better than repeat some of Harvey's observations. This can easily be done by procuring a sheep's "pluck" from a butcher's shop.

1. Note first the position of the heart between the two lungs, and then try to identify the two auricles and two ventricles by the aid of Fig. 30. Note the groove that

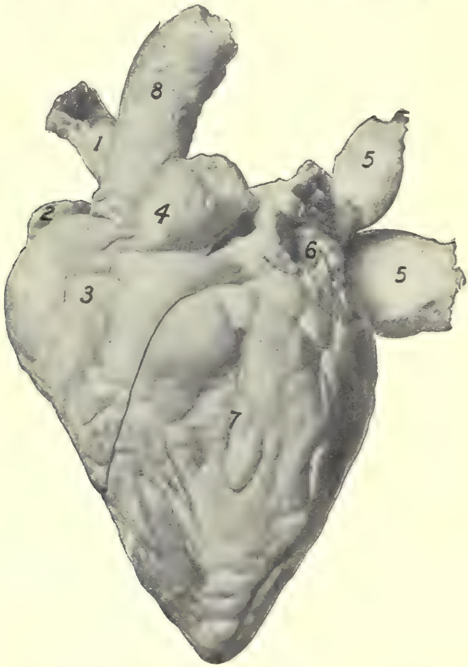

Fig. 30.—Sheep's heart from a photograph. 1, the descending vena cava; 2, the right auricle; 3, the right ventricle; 4, the pulmonary artery; 5, the pulmonary veins; 6, the left auricle; 7, the left ventricle; 8, the aorta.

runs obliquely downwards from right to left. This is the inter-ventricular groove and marks the boundary between the right and left ventricle. As shown in the figure, there is more of the left ventricle seen than there is of the right.

2. Make a cut from the superior to the inferior vena cava. Are there any valves where they open into the auricle? Make another cut at right angles to the first. This exposes the whole inside of the right auricle. Note its internal surface. Pour water into it from a slight height, and note the way in which the flaps of the tri-cuspid valve float upwards and close the opening.

3. Open the right ventricle by making a U-shaped cut parallel to the inter-ventricular groove, but at some distance from the groove, so as not to injure the internal parts. Note the internal surface of the ventricle. Observe the tri-cuspid valve from below. Find the opening of the pulmonary artery with your finger and trace its course and the branch to each lung.

4. Slit this artery open just where it leaves the ventricle, and find the three-flapped valve, the **semi-lunar,** which, when closed, prevents any back flow of blood in the ventricle (see Fig. 31).

The anatomy of the left side of the heart is very similar to that of the right. The chief difference is in the thickness of its walls. The right ventricle has to force the blood through the shorter circulation only; the left, has to force the blood through the long, or systemic circulation. This difference in the amount of work which each ventricle has to do shows itself in the differences between the thicknesses of their muscular

walls. The one which does the most work has the thickest walls—the left.

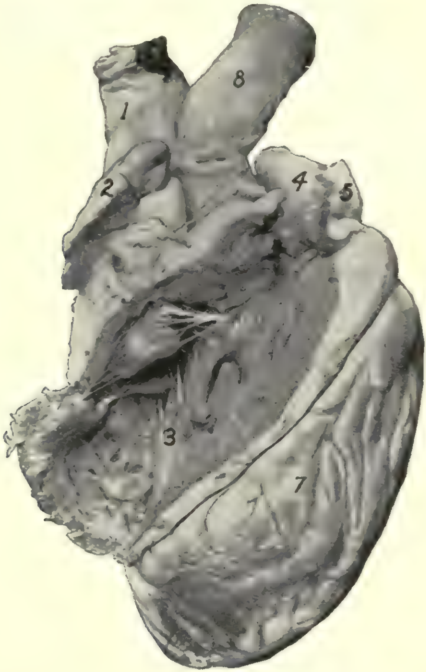

Fig. 31.—Interior of right ventricle of the sheep's heart. 1, the descending vena cava; 2, the right auricle; 3, the right ventricle opened and shewing the tri-cuspid valve and internal walls; 4, the pulmonary artery with semilunar valve exposed; 5, one pulmonary vein; 7, the left ventricle; 8, the aorta.

In both sides of the heart, the arrangement of the valves is such that they open in one direction only, and consequently the blood can flow only in one direction.

Care of Circulatory Organs.

1. The heart should not be exhausted by prolonged overwork, as in running races, rowing, or other athletic contests. "Athlete's heart" comes on as a result of severe and prolonged physical training.

2. Alcohol drinking increases the frequency of the beat of the heart, and diminishes its force. A heart that has been subjected to the strain of even moderate drinking will give out more easily under exertion or in disease. Prolonged drinking sometimes produces fatty degeneration of the heart. It also causes a degenerative change in the lining of the blood-vessels known as **sclerosis,** and this change may lead to rupture of the walls and sudden death.

3. The use of tobacco by boys frequently produces irregular heart action, sometimes fainting. It causes weakness and dilation of the blood-vessels. "Tobacco heart" in boys will keep them from success in athletic contests, and in any kind of work that requires much muscular exertion.

LESSON VI.

Regulation of the Blood Supply.

The quantity of blood passing through the different organs of the body is varying all the time. After a meal, that is, during the digestion of food, more blood goes to the stomach, intestines and liver, than when no digestion is going on. In the same way, during manual labor, or during great muscular exertion, more blood goes to the muscles than when they are at rest. Similarly, in cold weather, less blood is found in the capillaries of the skin;

in hot weather, more blood goes to the surface capillaries; and, generally speaking, the quantity of blood in any organ varies with the activity of that organ.

How then, it may be asked, is the flow of blood to different parts of the body regulated? In answer, it may be said that the quantity of blood going to any organ is regulated in two ways:—first, by changes in the heart beat; secondly, by changes in the bore or calibre of the artery, which carries blood to the organ.

If the heart beats faster and stronger than usual, then the general circulation must be quickened, and more blood must be sent to all the organs of the body. An opposite effect will occur if the heart beat becomes slower and feebler. The heart, in this respect, is precisely like a pump. If the handle of a pump is worked quickly and forcibly, more water flows away from the pump spout; whereas, if the handle is worked slowly and feebly, less water passes away. Increase and decrease, therefore, in the force and frequency of the heart beat alters the quantity of blood to every part of the body.

But it is different with the arteries. Nerve impulses going to the muscle fibres in the walls of these vessels make them grow larger or smaller in diameter, from time to time, and consequently more blood or less blood can be allowed to pass to various organs in the body, according to their varying needs. Thus, while chewing the food, the arteries leading to the salivary glands grow larger and allow more blood to pass to these organs. The greater blood supply enables them to secrete more saliva for the digestion of the food. In the same way, during digestion, the arteries which supply blood to the

stomach and intestines become larger in their bore, and allow more blood to pass to these organs. And here comes in a rule of health which everyone should obey, viz., never undertake any severe muscular exertion immediately after a meal. A little thought will make clear the reason for this rule. During digestion, as we have seen above, all the digestive organs require an increased blood supply, and they should get the increased supply from other parts of the body. But, if we run or labor violently after eating, the working muscles also make a demand for more blood, and, as a consequence, neither the muscles of the body nor the digestive organs can get the increased blood which they require for their work. Under these circumstances, it is usually the digestive organs which suffer, and indigestion results if the error is persisted in.

From the foregoing considerations, it will easily be seen that changes in the force and frequency of the heart beat produce **general effects,** that is, produce effects upon the blood circulation that are felt in every organ of the body ; whereas, changes in the calibre of the arteries produce **local effects,** that is, effects that are felt in special organs or parts of the body which temporarily need an increased supply of blood.

QUESTIONS AND EXPERIMENTS.

1. Count the heart beats or pulse beats (*a*) when sitting, (*b*) when standing, (*c*) when lying down, (*d*) immediately after taking any active exercise, as running. How does the beat vary in each case?

2. If the heart should beat faster than the average, seventy-two times per minute, how would the rate of the blood flow be affected? If slower, how?

3. What effect would lying down have upon bleeding as compared with standing up? How would muscular exercise, walking or running, affect (1) blood flow, (2) hæmorrhage.

4. What is the pericardium? What fluid is found in the pericardial sac?

5. What are the two sounds of the heart? Their cause?

6. Locate some of the principal arteries in the upper and lower extremities. In case of hæmorrhage from the arm artery, where would you place the bandage?

LESSON VII.

Respiration.

Respiration is the act of breathing. The essential part of the process is the passage of the oxygen of the air into the blood of the lung capillaries. In other words, all animals in breathing use up a part of the air. The loss in volume is not easily seen, but the fact that there is a loss was proved many years ago by John Mayow. "I have found," he says, "by experimenting with animals that the air is by the breathing of animals reduced in volume by about $\frac{1}{14}$th." The substance thus taken from the air is oxygen.

But this substance may be taken from the air in other ways besides breathing. In all ordinary burning, as of candles, lamps, or stoves, oxygen disappears from the air, as any boy may prove for himself.

Before teaching this lesson, the teacher should have taught Nature Study for Form IV, "The Atmosphere, etc.," page 61 of the new regulations.

1. Light a short piece of candle and float it on a flat cork in a soup plate filled with water. Then cover the floating candle with a jar as in Fig. 32, pressing the jar down into the water. Mayow's experiments were like this one, but instead of a candle he used small animals.

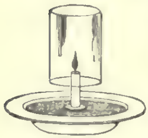
Fig. 32.

In less than a minute the candle "goes out," because all the oxygen has been used up. The water then rises in the inside of the jar. The gas which remains is **nitrogen** and this will not support life, that is, animals cannot live in it.

Animals not only use up the oxygen of the air in breathing, but they give off from their lungs a gas, carbon dioxide, which resembles oxygen in having no color and no smell. That such a gas is coming from the lungs all the time may be proved as follows.

2. Make some limewater by shaking up quick-lime in a pitcher with ordinary drinking water. After the mixture has stood for an hour or two, or until the water has become perfectly clear, pour off some of it into a tumbler. Then take a small glass tube, or straw, and bubble air from the lungs through the limewater. It turns a milky color on account of the carbon dioxide from the lungs uniting with the lime dissolved in the limewater.

These experiments and many similar ones go to show that in respiration oxygen is being continually taken from the air, and carbon dioxide given to the air. If this were to go on for any great length of time, animal life would soon come to an end, on account of lack of

oxygen and excess of carbon dioxide. But, in 1771, Priestley discovered that the effect of ordinary combustion and of animal life upon the air is exactly balanced by the effect of plant life upon the air. His experiment to prove this can easily be repeated by any diligent pupil in the following manner.

3. Repeat the first experiment described above. Now, without admitting any fresh air, arrange a sprig of mint or a growing hyacinth bulb under the jar, so that the roots of the plant will be immersed in the water. Place the whole in a window for a week or ten days. At the end of this time, test the air under the jar with a burning candle, again taking care that no fresh air is admitted to the jar. It will be found that the air under the jar supports the combustion of a candle just as well as ordinary air.

Priestley obtained exactly similar results when he used mice under the bell jar instead of a burning candle.

We conclude, therefore, that animals in breathing take oxygen from the air and give out carbon dioxide. Plants use this carbon dioxide for their growth and return oxygen to the air. The vitiating effects of animal respiration upon air is balanced by the restorative effects of growing plants on air. This is what is meant by the reciprocal relation of plants and animals as regards the atmosphere.

Care of the Respiratory Organs.

1. We should take plenty of vigorous out-of-door exercise, such as running, rowing and swimming, in order to develop the chest and muscles of respiration.

2. We should avoid working in an atmosphere that contains much dust, and we should try to keep our houses as free from dust as possible. For this reason, after a room has been swept, the dusting should be done with a damp cloth. Bare floors are more healthful than carpeted ones.

3. Tobacco smoke irritates the throat and may even cause sore throat. If the throat be sore, smoking generally makes the trouble worse.

LESSON VIII.

Composition of Air.

Before considering the respiratory mechanism it will be necessary to give the composition of the air. Its average composition is about as follows:—

Oxygen - - -	206·1	cub. centimetres.
Nitrogen - - -	779·5	" "
Water vapor - -	14·0	" "
Carbon dioxide -	·4	
	1000·0	

Besides these, there are traces of ammonia, organic matter from animals or plants, dust and smoke. These substances are the impurities in air, and, when present in large quantities, tend to undermine the health and spread disease.

EXPIRED AIR.

Expired air differs from inspired air in four particulars:

1. It is about the temperature of the body.

2. It is saturated with water vapor.

3. It contains about 4% more carbon dioxide and about 5% less oxygen than inspired air.

4. It contains traces of organic matter from the lungs and air passages.

RESPIRATORY MECHANISM.

In harmony with the facts of respiration, as detailed in the preceding lesson, we find that the muscular mechanism is designed in such a way that the oxygen is carried as quickly and regularly as possible to the tissues, and the carbon dioxide carried out. The demand of the tissues for oxygen is imperative. It cannot be resisted for longer than about five minutes without causing death. Stoppage, therefore, of oxygen either into the lungs, or of the circulation of the blood through the lungs, alike produce symptoms of suffocation.

Now, the first problem is: how does the oxygen get down into the air sacs of the lungs?

INSPIRATION.

The chest is an air-tight box. In inspiration its dimensions enlarge in all three directions. The diaphragm being curved upwards, when it contracts in

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Before teaching the mechanism of respiration, the teacher should have gone over with the class that part of Nature-Study for Form IV which treats of "air and liquid pressure . . . . diffusion," page 61 of the new regulations.

inspiration, moves downwards towards the abdominal cavity, thus increasing the dimension of the chest from above downwards. There are two layers of muscle

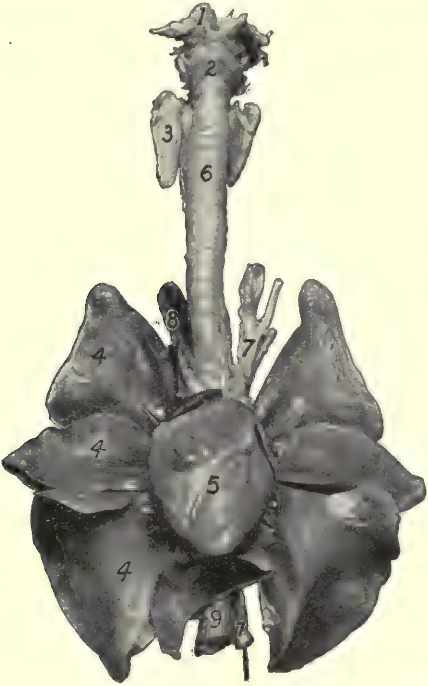

Fig. 33.—Lungs, trachea and heart of the cat. 1, the epiglottis; 2, the larynx; 3, one lobe of the thyroid gland; 6, the trachea or windpipe; 4, 4, 4, lobes of the lung: the lobed structure facilitates the enlargement and constriction of the lungs; 5, the heart: the oblique line under the figure 5 shows that more of the right ventricle is seen in front than of the left ventricle; 7, the aortic arch with branches, the lower figure 7 is the aorta just where it passes through the diaphragm; 8, the descending vena cava where it enters the right auricle; 9, the lower end of the gullet; higher up it is hidden behind the lungs and windpipe.

lying between the ribs, and known as the **external** and **internal intercostal** muscles. The external layer in contracting lifts the ribs and breast-bone, thus increasing the diameter of the chest from front to back, and also from side to side. This enlargement of the chest in all three diameters causes enlargement of the lungs, and as a consequence, between eighteen or twenty cubic inches of air pass into the nasal passages, throat, larynx, wind-pipe and larger bronchial tubes. This air does not pass directly to the air sacs of the lungs. It is known as **tidal** air. In quiet or ordinary breathing, there is about 150 cubic inches of air always in the lungs, and known as **stationary** air. How then does the oxygen of the tidal air get down to the air sacs or alveoli, where the oxygen is passing into the blood all the time? In answer, it may be said that the oxygen **diffuses** downwards, and so perfectly and rapidly is this done, that the air in the air sacs differs but little in composition from expired air. The carbon dioxide diffuses upwards from the air sacs until it reaches the tidal air.

The tidal air, in entering the nasal passages and throat, comes into contact with the mucous membrane, and in consequence is warmed almost to the temperature of the body. It also takes up water vapor from these moist surfaces. Accordingly, this warm moist air, on passing into the outer air in cold weather, produces a kind of little fog. We are then said to "see our breath."

EXPIRATION.

In ordinary breathing, the weight of the chest is sufficient to diminish the size of the chest and force the air out of the lungs. In forced or labored breathing,

however, the expulsion of air is aided by the contraction of the internal intercostal muscles, and by that of the abdominal muscles. One can see this easily enough by trying to force as much air as possible out of the lungs.

CARE OF RESPIRATORY ORGANS.

1. Carbon dioxide is not the most harmful substance in expired air. Dust particles and organic matter, especially disease germs, are the dangerous ingredients. The carbon dioxide in a room can be measured, and when it amounts to six volumes in 10,000, the air is unfit to breathe, not because of the excess of carbon dioxide, but because this excess is always accompanied by excess of dust particles and organic matter.

2. Lack of oxygen in the air we breathe lessens nerve sensibility and relaxes the muscles. Confinement in unventilated rooms, or the crowding of many people in small rooms, lowers the general health and helps to spread that terrible scourge, consumption.

3. Bedrooms should not only be well ventilated at night; but, in the morning, the sheets and blankets should be removed, and the windows opened for at least an hour.

LESSON IX.

ANIMAL HEAT.

Just as the heat of a stove or furnace comes from the burning of fuel, so the heat of the body comes from the gradual burning of its own tissues. The human body is from one point of view a living stove. It gets its fuel in the shape of the food which we eat. Not that the food

is directly burnt in the body as fuel is in a stove. It must first be digested and assimilated. The carbohydrates and fats are temporarily stored in the body and are burnt as needed, that is, they unite with the oxygen which is brought to the tissues by the blood, and, in being thus oxidized, furnish body heat and bodily movement. The proteids are used in making good the waste of the tissues, but sooner or later the tissues break down, and therefore all three kinds of foods may be said to be burnt in the body, and in burning give rise to the waste substances, carbon dioxide, water, urea, and others of less importance.

The distribution of the heat and the equalization of the temperature in various parts of the body is brought about by the circulation of the blood.

A man who drinks alcohol in cold weather thinks he is warmed by it. In reality the alcohol lowers the heat of the body. In arctic expeditions the men who endured the cold with least inconvenience or suffering were the men who abstained entirely from its use.

Nervous Mechanism.

The respiratory movements are under the control of the nervous system. The diaphragm and intercostal muscles are supplied with nerves from the brain and spinal cord, and along these, impulses pass to the muscles and make them contract with every breath we draw. If these nerves be cut the respiratory movements cease. The part of the nervous system which controls the issue of these nerve impulses is located in the medulla, and is known as the **respiratory centre**.

The rate of respiration varies greatly at different ages and under different circumstances. At birth, the rate is about forty per minute; at five years of age, from twenty to thirty per minute; in middle life, from sixteen to eighteen; and in old age, it has increased a little again to seventeen or nineteen per minute.

Asphyxia may be caused by obstruction of the windpipe, as by a lump of food, or by strangulation. Or, it may be caused by the lungs becoming filled with an inert gas, or a mixture of gases containing too little oxygen. Or, it may be caused by the lungs being filled with water or other fluid, as in drowning; or, finally, it may result from the paralysis of the nervous mechanism of respiration, as in taking morphia, curare, or chloroform in excess.

Drowning.

A person, who has been asphyxiated by drowning and is unconscious, should first be turned upon his face with his head low, in order to allow the water to run out of his mouth and lungs. Then, warmth should be applied to his body, if at all convenient, and artificial respiration started as quickly as possible. To do this, the patient should be placed upon his back with a block of wood or folded coat under the back. Then one person should raise the patient's arms horizontally above his head and lower them again to his sides. As the patient's arms reach his sides, another person should press upon the stomach and edge of the chest, so as to diminish the size of the chest and aid in the expulsion of air. These movements should be continued at the rate of about seventeen per minute. Efforts at resuscitation should be kept up for an hour or even longer.

FIG. 34.

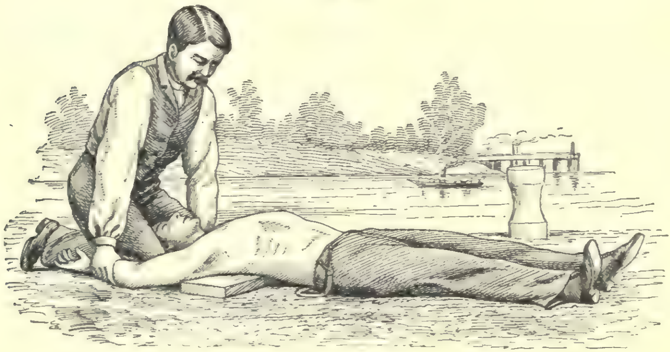

FIG. 35.

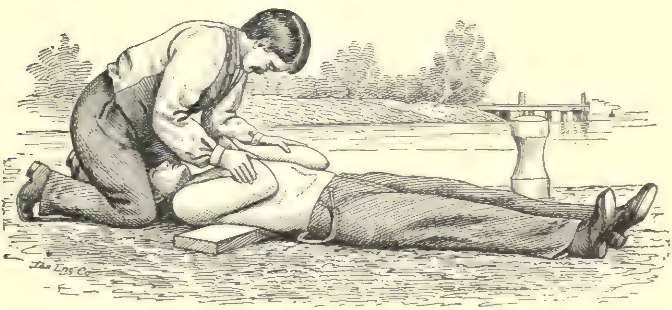

FIG. 36.

Figs. 34, 35 and 36 show how artificial respiration can be carried on by one person. Teachers should require pupils to practise it on each other.

Another Method.

Two objections have often been urged against keeping the patient lying upon his back while carrying on artificial respiration. The first is that the tongue may slip backward and close the entrance to the windpipe. The second objection is that the water, mucus and froth in the windpipe prevents the free entrance of the air.

Professor Schafer, therefore, advises that the patient be placed "face downwards on the ground with a folded coat under the lower part of the chest. Not a moment must be lost in removing clothing. If respiration has ceased, artificial respiration must be commenced at once; every instant of delay is serious.

"To effect artificial respiration, put yourself astride the patient's body, supporting yourself on one knee on one side and one foot upon the other side. Place your hands flat over the lower part of the back (on the lowest ribs), one on each side, and gradually throw the weight of your body forward on to them so as to produce firm pressure—which must not be violent—upon the patient's chest. By this means air (and water if there is any) is driven out of the patient's lungs. Immediately thereafter raise your body slowly so as to remove the pressure, but having your hands in position. Repeat this forward and backward movement (pressure and relaxation of pressure) every four or five seconds. In other words, sway your body slowly forwards and backwards upon your arms twelve or fifteen times a

minute without any marked pause between the movements. This course must be pursued for at least half an hour, or until the natural respirations are resumed.

"Whilst one person is carrying out artificial respiration in this way, others may, if there be opportunity, busy themselves with applying hot flannels to the body and limbs and hot bottles to the feet."

Care of Respiratory Organs.

1. Alcohol-drinking relaxes the mucous membrane of the throat and lungs and tends to produce congestion and inflammation of the pharynx and bronchial tubes.

2. Sore throat and coughs should be attended to at once. Those who cough should not spit upon the floor, but into cuspidores which can be disinfected. Disease-germs in spittle that dries upon the floor are subsequently spread by sweeping, and as a result the disease may be communicated to others.

3. Direct sunlight kills disease-germs, and therefore sunlight should, as far as possible, be admitted to every room in a house.

LESSON X.

Excretion.

We have already learned that the waste materials of the tissues are carried out of the body by four channels: (1) by the lungs in expired air; (2) by the skin in sweat; (3) by the kidneys in urine; and (4) by the alimentary canal.

The lungs discharge most of the carbon dioxide and considerable water.

The skin excretes a little of the salts which have been taken in with the food, a little carbon dioxide, a large but variable quantity of water and a little urea.

The kidneys discharge nearly all the urea and allied substances, the greater portion of the salts, a large amount of water, and a small quantity of carbon dioxide.

Only a little waste is discharged by the alimentary canal—chiefly the unused portions of the digestive juices, including the true excretions contained in the bile.

THE KIDNEYS.

The kidneys are a pair of organs, each about four inches long, two and a half broad, and one thick. They lie in the abdomen, one on either side of the spine, and extend a little below the level of the last rib.

A kidney is convex on one side and concave on the other (Fig. 37). The renal artery—a branch from the

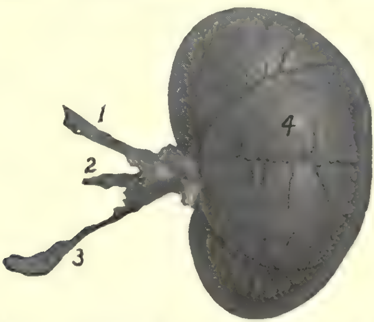

Fig. 37.—Cat's kidney viewed from one side. The dark lines and their branches are injected blood-vessels. 1, the renal vein. 2, the renal artery. 3, the ureter. 4, the body of the kidney.

abdominal aorta—enters the organ at the concave side, or hilum. This distributes an abundant supply of blood

to the organ. The blood is carried out of the kidney by the renal vein. The capillaries run among and close alongside of a large number of little tubes, known as the uriniferous tubules. In fact, the kidney may be described as consisting of an immense number of blood capillaries and uriniferous tubules, with enough connective tissue between them to hold the whole together. The function of the tubules is to pick out the waste from the blood, and this is why they lie between and as close to the blood capillaries as possible.

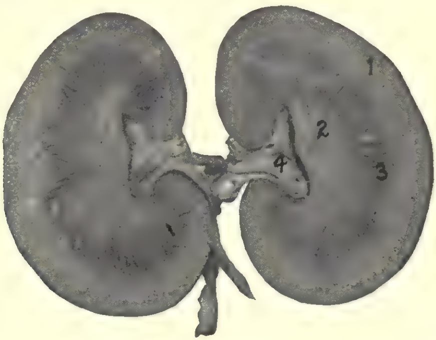

Fig. 38.—Cat's kidney cut open lengthwise. 1, the cortex. 2, the medulla. 3, the boundary between the two, showing numerous injected blood vessels. 4, pelvis of the kidney which continued outwards narrows into the ureter.

The outer ends of the tubules lie in the cortex and their other end opens into the pelvis (consult Fig. 38), so that the waste from the blood—water, urea and salts are conveyed down the tubules to the pelvis, thence down the ureters to the bladder.

The kidneys not merely remove the waste which the blood regularly receives from the tissues, but they

remove perfectly normal constituents of the blood as soon as these occur in excess. If the blood tends to become too watery the kidneys begin to excrete a watery urine; if the blood becomes too alkaline the kidneys begin to secrete a less acid or even an alkaline urine; if the blood receives any abnormal substance in the food, or as a medicine, the kidneys promptly begin to remove it. Similarly in the disease diabetes, or sugar in the urine, the trouble is not in the kidneys. It is in the pancreas, or liver, or elsewhere. Too much sugar is thrown into the blood, and the kidneys begin to remove it so as to reduce the amount of sugar to the average of ·2 per cent.

The great work of the kidneys, therefore, is to regulate the condition of the blood and keep it pure.

Care of the Excretory Organs.

1. An important rule is to keep the kidneys in good working order. This may be done to some extent by drinking plenty of water. Excess of water, especially of mineral water, is stored temporarily in the tissues, then removed by the blood, and finally excreted by the kidneys. The effect of this is to flush out waste from the tissues, and prevent concentration of the urine.

2. All substances that tend to irritate the kidneys should be avoided. Consequently, waters that contain an excess of the earthy minerals, like lime salts, should be avoided. So should indulgence in alcoholic drinks.

3. The fæces consist of undigested portions of the foods and of tissue waste discharged into the bowel. This matter should be discharged every day, and, as far

as possible, at some regular hour, preferably after breakfast. If not removed, they tend to poison the system and produce drowsiness, headaches and debility. Constipation is chiefly due to errors in diet, and should be treated from this point of view, not by the use of medicines. Tight clothing and lack of exercise may help to induce constipation, but in most cases plenty of Graham bread, porridge, green vegetables and fruits, such as prunes, figs, berries and apples will remove the trouble. Sipping a glass of hot water upon rising in the morning sometimes proves helpful.

LESSON XI.

Disease and Health.

It generally happens that a condition of ease, as regards bodily health, passes by almost insensible gradations into a condition of *dis*-ease. This is usually the case, where a person has, through ignorance or indifference, broken some of the ordinary rules of health for a considerable length of time. If a man is born with a fine constitution, he may violate many of the laws of health as regards diet, exercise, fresh air, or the use of stimulants and narcotics ; but, sooner or later he pays the penalty of his wrong-doing, in the discomfort or pain he is made to suffer. But it is quite different with a person who inherits a delicate constitution. In this case, the tendency to become diseased is inherited from parents or near relatives. Even if specific diseases are not transmitted from parents to offspring, there is no doubt that weakling or delicate children inherit organs and

tissues of body that render them liable to be attacked by certain diseases. A strong man is often exempt from disease just because he is strong; a comparatively delicate man may keep himself free from disease, by early recognizing his weakness, and, as a consequence, carefully conforming to all the ordinary laws of health.

A second source of disease is from the effects of climate or of sudden changes in the weather. Exposure to rain and cold is a fruitful cause of disease of the respiratory tract and lungs, and probably also of muscular rheumatism. The fact that cold profoundly affects the health of vast numbers of the population is proved by the reports of the Register-General in England. Every autumn a fall of a few degrees in temperature is immediately followed by an increased death-rate. In America, during the heat of July and August, the death-rate among children always increases.

A third cause of disease is from injuries due to accidents. Wounds, bruises, sprains, dislocations of joints, fractures of bones, all come under this head, and need not be dwelt upon at any length. Tumors, the cause of which is unknown, also belong here.

Lastly, we have, as a cause of disease, the action of very minute living bodies, or bacteria, which, finding a lodgment on external or internal parts of the body, start to grow. In doing so, they live on the tissues, cause their inflammation and decay and form poisons. Under this heading we include all contagious and infectious diseases, such as consumption, pneumonia, influenza, typhoid fever, diphtheria, scarlet fever, measles, small-pox, cholera, whooping cough, some scalp and skin diseases, and such simple troubles as boils and abscesses.

Now, we cannot all have strong constitutions, but we ought all, sickly and robust, to take care of the general health. The following simple rules, sum up nearly all those that have been given in the preceding pages, and a systematic practice of them will do much to make even the sickly strong.

1. Eat plenty of plain, wholesome food.

2. Wear clean, dry, loose, comfortable clothing.

3. Take plenty of exercise in the open air, either in the form of work, or in playing games.

4. Take adequate rest and sleep in well-ventilated rooms.

5. Set apart some time for pleasant recreation.

6. Keep the hair, teeth, mouth, throat and skin scrupulously clean.

7. Be regular in the practice of good bodily habits.

8. Avoid the use of stimulants, such as strong tea and coffee. Opium, tobacco, alcohol, cocaine, etc., are narcotic poisons and should be avoided altogether.

If we follow these general rules, and maintain the strength of the body at a high level, we shall not only escape the diseases that are caused by persistent violations of the laws of health, but we fortify ourselves against those which are caused by changes of climate or weather. Nothing, of course, will ever exempt us from the injuries which result from accident ; but it is always well to know that, when we do become the victims of accident, good general health is the first requisite for a rapid recovery. As regards diseases due to bacteria, here again robust health counts for much. The weak

are often attacked when the vigorous escape; or if they do take an infectious disease, they survive the attack when the delicate succumb.

LESSON XII.

Bacteria and Infectious Diseases.

Bacteria are exceedingly small plants, so small, in fact, that they can be seen only with the aid of a powerful magnifying glass. Some of them are quite harmless, so far as our health is concerned. Some are very useful to man, as for example those which give flavor to the best butter and cheese. Some give rise to disease. Bacteria of all kinds, or the germs from which they grow, are in the air, water, soil, and even within our own bodies. As the rotting or putrefaction of dead plants and animals is due to the growth of bacteria, it is important to know some of the conditions that favor or retard their increase in numbers. In the first place, moderate warmth favors their growth. Cold stops their increase, but does not kill them. Moisture favors; dryness retards their growth. Repeated heating up to the boiling point of water kills bacteria, and this is the method employed in manufacturing canned meats, vegetables, and fruits. The boiling kills the bacteria and their germs, and consequently the canned material does not putrefy. The principle of cold storage is different. Here, the freezing simply stops putrefaction during the time that the meat is frozen. As soon as the temperature rises above freezing, the activity of the bacteria is resumed and putrefaction goes on again.

There are comparatively few disease-producing bacteria. Probably some twenty-five different diseases are produced in this way. Each separate disease is caused by its own special organism. Disease-producing bacteria are not so widely distributed as the harmless or useful ones, but are limited to localities in which the diseases are prevalent, or to substances or articles which have come from such localities. These bacteria pass from the bodies of the sick in exudations from the mouth, nose and throat, as in diphtheria and consumption; or they pass from the patient in the fæces, as in typhoid fever. Scarlet fever organisms probably pass off with the scales of the scarf skin. Spread from these different sources, and especially when the exudations have dried, the disease-producing bacteria float about in dust, or live for a long time in soil, air or clothing, and, when they happen to get into the body of another person produce the same disease there. Sewer-gas, milk, water, uncooked vegetables or fruit, and occasionally insects (flies) may all assist in the dissemination of disease.

LESSON XIII.

Dirt.

"Dirt is any foul or filthy substance, as excrement, mud, dust."

In this lesson the word "dirt" will be used in speaking of dust, mud, or filth, which contains vast numbers of disease-germs or microbes, as nearly all dirt does. The soil of the primitive forest, or of the virgin prairie, or the sand and gravel of the seashore are not dirty. On the

contrary, they may properly be spoken of as clean, because they are not usually the bearers of disease-germs.

It is in thickly-settled parts of a country district, and especially in large towns and cities, that we find disease-bearing dirt. The mud and dust of towns often consist of dung, excrement, or filth, and this kind of dirt may be teeming with disease-germs. Streets and roads, over which there is a great amount of traffic are particularly dirty. Such thoroughfares are used by all sorts of dirty animals—horses, dogs, birds, and by men equally dirty. Many loads of manure and rubbish of all kinds pass along them every day. The droppings from diseased animals, or the sputum from people who are suffering from consumption, diphtheria, or influenza, are frequently deposited upon streets or side-walks.

This dirt clings to the feet, is carried to our homes, and, when dried, is scattered through the house by sweeping and dusting. In this manner it may pass to our food, and thus find entrance to the body.

Again, the dirt on the street, when dried up, soon becomes reduced to fine dust. This is readily lifted by the wind and blown through open doors and windows ; or it may be driven through cracks and crevices into houses. Once it gets within our houses, it is possible for it to alight upon food or drink, and having entered the body, it may, through the disease-germs which it carries, set up disease among some of the inmates of the house. Within a house, dirt may be the means of spreading disease from one member of a family to another. For example, when a person is suffering from typhoid fever, the germs which are peculiar to this disease pass off

from the body in the bowel discharges, urine and sputum. Consequently, if any of this dirt soils linen, bed-pans, or handkerchiefs, it may pass thence to the hands of laundress, nurse or maid-servant. From the hands of these persons it may be transferred to dishes, knives, spoons, food, or drink, and be thus passed into the body of another person and communicate the disease to him.

Dirt, then, is a dangerous thing, whether we find it on the person or clothing, in our houses, on the streets, or in the rubbish heap of the back-yard. It is true that some people are strong and healthy, who are nevertheless uncleanly in habits and in body. But it will generally be found in this case that they have been born with unusually robust bodies, and that they are healthy in spite of the dirty surroundings in which they live. The strong bodies which they have inherited from their parents enable them for some years to break almost every known law of health. They may go half-clad in cold weather, may get soaked through with rain, may wear wet clothing until it dries upon them, may eat poor food, may frequently get drunk, and may continue all this for years just because they are exceptionally strong; but, sooner or later, their strength will become impaired, and then they, too, will suffer from the effects of dirt and filth just like their weaker and less fortunate neighbors.

LESSON XIV.

Dirty Water.

The ordinary sources of the water which we use for household purposes are wells, springs, rivers, lakes, ponds, rain and melted snow. Water derived from rain and snow, as it falls from the upper sky, is the purest natural water that we can procure. When, however, rain reaches the earth, and when snow melts, they wash away with them material derived from the soil and become discolored—brownish, muddy, or turbid, and the water is then generally known as **dirty** water. Such water, however, may be perfectly wholesome, that is, it may be harmless for domestic use. On the other hand, when water from any source becomes mixed with excrement, or substances thrown off from animal bodies, such as spit, urine, or bowel discharges, it is then said to be **polluted.** Polluted water is always dangerous to use for household purposes. The most polluted water to be found anywhere is in the sewers of towns and cities. Into them are emptied waste waters from sinks, drains, laundries, stables, butcher shops, baths, water closets, and generally the washings of streets and gutters. In short, all the filth that we can possibly conceive of, as derived from a modern town, finds its way into the sewers. Now if, in any way, sewer water mingles with drinking water and thus finds entrance into the body, it becomes dangerous to human life. For sewer-water often contains disease-producing bacteria derived from animal excrement, and when these enter the body in drinking water they often produce

certain well-known diseases. Perhaps the disease that is most frequently transmitted by polluted water is typhoid fever; but, diphtheria, and even consumption, may be transmitted in this way.

It is easy to understand how clean river waters, brooks, creeks and the like may become polluted. They are the natural drains of the region through which they flow. Into them, at many points along their course, are emptied the sewage of towns and villages, the discharges of factories, the drainage of barnyards and fields that have been covered with manure. Privies also overhang streams, or stand near to them as the most convenient way of disposing of excrement. Well-water also may become contaminated by proximity to these various sources of pollution. Even springs, which are usually the source of the most wholesome kind of natural waters, may become dangerously polluted with surface water which has come from barnyards, sewers, privies or dirty soil.

The appearance of water is no safe guide to its purity. Water may be turbid or dirty-looking, and yet be perfectly safe for drinking. On the other hand, it may look clear and sparkling, and yet contain the germs which give rise to diarrhœa or typhoid fever.

The only absolutely safe rule to follow, when there is an epidemic of typhoid fever in a city or town, is to boil the water for at least half an hour, and then cool it before drinking.

LESSON XV.

Prevention of Infection.

We can prevent the spread of diseases that are caused by bacteria in four ways: (1) by disinfection, (2) by isolation, (3) by producing immunity to the disease, and (4) by keeping the general health of individuals up to a high standard, and the neighborhood in a perfectly sanitary condition as regards water supply, fresh air, sewerage and cleanliness of yards, houses, lanes and streets.

Disinfection.—This is the name given to various ways of killing disease-producing bacteria. We must disinfect the floor and walls of a sick room; the beds, bedding and furniture; the clothing, dishes, excreta; and, in short, everything that leaves the patient's room.

1. One method of disinfecting certain substances or articles is to burn them.

2. Another method is to boil them for twenty or thirty minutes.

3. A third method is to wash articles in solutions of certain chemical substances in water. The most important disinfecting substances are corrosive sublimate, carbolic acid, chloride of lime, formaldehyde (formalin) and sulphur dioxide from burning sulphur.

The special method to be employed in any given case will depend upon circumstances. Articles like cloths that have been used to receive the expectorations from consumptive or diphtheritic patients should be burnt. Some articles of clothing may be disinfected by boiling; others by prolonged dry heat in a disinfecting oven.

The excreta should be thoroughly mixed with chloride of lime, or other good disinfectant, and allowed to stand for some time before being disposed of.[1] Rooms and furniture should be disinfected by closing all openings, and filling the room with formaldehyde gas, or the fumes of burning sulphur for twenty-four hours.

Isolation.—This is another method that is employed to prevent the spread of infectious diseases. The patient is kept in one room, and the rest of the family are not allowed to enter it. Special precautions are taken so that the nurse and doctor shall not spread the disease in leaving the room. The house itself is placarded, so that neither neighbors nor strangers may visit it. If there are children belonging to the house, they are kept from school. In short, isolation means that those suffering from any infectious disease are kept by themselves and away from all others, as far as this can possibly be done. In this way, the germs of contagious diseases are confined to one room, or one house, or hospital, and thus the spread of the disease through a district is effectually prevented.

Immunity.—This means a condition of body in which a person is not liable to take an infectious disease when exposed to it. Generally speaking, when a person has had an infectious disease once, like smallpox, scarlet fever, mumps, or yellow fever, he is not likely to take it a second time; that is, he is said to be immune to it. In the case of smallpox, a person can be made immune

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[1] It is absolutely essential that a disinfectant should have ample time to act on and kill the bacteria. Chloride of lime requires at least an hour to do its work.

to this disease by being **vaccinated**; that is, he takes the disease in what may be called a very mild form, and thereafter for some time he is immune to the disease.

Diphtheria is a disease in which we can produce immunity in a different way. The part of the body that shows the local effects of diphtheria is the throat. Here white patches occur, and at these points, the bacteria are growing in immense numbers, causing not merely swelling, inflammation and death of the mucous membrane, but producing also poisonous substances called **toxines.** These toxines become absorbed into the body and make the patient very sick. He has headache, fever, nausea, and suffers great pain. If he is not robust, he dies; if he is sufficiently strong, his blood begins making an antidote to the toxines, called **antitoxines.** This destroys the poison generated by the disease, and the patient recovers in due time.

But now-a-days, we do not wait until a patient's blood has generated the antidote to the toxines of diphtheria. We have learned how these antitoxines may be obtained from the blood of a horse to which diphtheria has been communicated: and these antitoxines are for sale in almost every drug shop. And so, when a patient has diphtheria now, a physician injects into his system a few doses of diphtheria antitoxine and the patient is soon cured.

Besides these three means of preventing the spread of infectious diseases through a community, there are a few rules that each individual should observe if he wishes to avoid "catching" or spreading disease.

1. He should not spit upon floors or sidewalks.

2 He should not put into his mouth articles that are handled by a number of people, such as coins, pencils, pipes, drinking vessels at a public fountain, gum, pea-blowers, or whistles.

3. Wash the face and hands often, if they have been exposed to the dust and dirt of a city or town ; and avoid specially putting the fingers in the mouth if they have not been washed for some time.

4. Do not cough into people's faces, nor allow others to cough into yours.

LESSON XVI.

A Living Body.

If we watch a living animal, such as a man, dog or cat, we can easily see that it differs from a dead animal in a number of ways :—

1. The living animal moves.

2. Its movements seem often to be started by things outside of the animal itself.

3. The animal gives out heat and makes heat.

4. It takes in food from time to time and breathes.

5. It throws out by the skin, the lungs, and the kidneys, stuff that is of no further use in the body and that is known as dead waste.

A dead animal does none of these things except give out heat, and the loss of heat goes on until the flesh decays and there is at last nothing left of the dead but " dust and ashes."

How a living animal moves, how it breathes, how it makes heat, how it changes dead food into living flesh and bone, how this flesh is changed into dead waste, and how this dead waste is gotten out of the animal's body, are all hard questions to answer, and thus far no physiologist, however wise, has been able to answer them fully. But bright boys and girls, by keeping their eyes open and watching closely how animals around them live and move, will be able in time to answer these questions for themselves, at least in part.

The great matter is that a pupil should first see clearly what the question is to which he wishes an answer. Having made this clear in his own mind, the next thing is to watch what is going on in ourselves and in other animals, and after learning all we can in this way, to ask Nature some questions which we do by trying some experiments. For example, we have already learnt that the bending of the forearm towards the arm is caused by the mass of flesh, which lies at the front of the arm, shortening and thickening and pulling upon a tendon that is attached to one of the bones below the elbow.

Now the next point, evidently, is to find out something about this fleshy mass. Of course, we cannot cut the arm open to examine it, but we can go into a butcher's shop and examine parts of a sheep or beef which may be hung up for sale. Under nearly all parts of the skin, which has been removed, we may find lean meat or muscle tissue. Close examination of any large mass of this will show that it can be easily and naturally subdivided into smaller masses, each of which is really a separate muscle. There are hundreds of separable

muscles in the body of any of the higher animals. Altogether, the muscles make up nearly half the weight of the human body. If we take a single muscle, and look at it closely, we can learn something about its structure as viewed by the naked eye. It usually consists of three main parts—a belly and two tendons, one at each end. Cut out from the belly a block of flesh about a half-inch square, and have a piece of well-boiled lean meat at hand for comparison with the raw flesh.

1. Pull apart a piece of each. They separate into pieces called **muscle bundles.** Note the varying size and shape of these.

2. What kind of substance binds the muscle bundles together? Scrape the surface of the fresh meat across the cut ends of the bundles and examine them before answering.

3. Do you find any fat lying between the bundles? Any blood? Or blood-vessels?

4. Are the muscle bundles attached to a strong white band or to a cord at either end? If not, procure a piece of meat in which such a band is present and observe how the soft lean meat is attached to the strong white fibres.

The belly of the muscle is the soft red fleshy part As we have seen, the belly is composed of muscle bundles. These consist of two parts—a jelly-like reddish part that easily comes away when fresh meat is scraped across the grain with a knife, and a tougher whitish stringy mass that remains behind. This stringy part is **connective tissue,** and consists of fine threads

and sheets which surround the soft semi-solid reddish part. It is continued along the length of the parallel muscle bundles and is collected to form the strong tendinous bands or cords which we find at the ends of the gross muscle. It is by means of these tendons or cords that muscles are joined to bones.

A muscle which becomes shorter, thicker and harder, that is, a muscle that **contracts** when we **will** that it should contract is known as a **voluntary** muscle. Most of the muscles of the arms, legs and trunk are of this kind. But, in the innermost parts of the body, as in the intestines, are many muscles arranged in sheets. These contract without our knowing anything about their movements, and such muscles are known as **involuntary** muscles.

QUESTIONS AND EXPERIMENTS.

1. Clasp the fleshy mass at the back of the middle of the upper arm. This is known as the **tricep's** muscle. The corresponding mass in front is the **biceps.** What is the function or work of each of these?

2. What is the function of the thick mass of muscle at the base of the thumb?

3. Try to find out where the muscles lie which are joined to the tendons which you can see and feel at the wrist. To answer this question bend and straighten first the wrist, and then the fingers a number of times.

4. Raise and lower yourself a number of times on your toes, and then try to locate the muscle of the leg which lifts the weight of the body in walking.

5. Try to find the muscles which force the teeth in the lower jaw against those in the upper.

6. Mention some movements going on in the body which we cannot stop for any length of time. Is winking one of them?

7. What parts of the body are moved in looking around us? In touching an object? In hearing a slight sound? In smelling a faint odor?

8. What effect have exercise and work upon muscle? Which arm is the larger? Which leg the stronger? Why?

9. Try to find out how an earthworm crawls along the ground.

LESSON XVII.

The Nervous System.

Before going on further with our study of muscle we must acquire some general knowledge of the nervous system. This is the great governing system for all the functions carried on in the body. It starts, stops, or controls all muscular movements; it determines whether glands shall secrete their juices or not; it regulates the flow of blood to the different parts as may be needed; it receives and sends out messages to every part of the body; it gets information through eye, ear, skin, mouth, nose, and muscle, of changes going on in the world around us; it stores these as memory; and it decides upon present and future conduct. The nervous system, therefore, is not only the governing system of the body, it is the seat of intelligence.

There is no nervous system in the lowest forms of animals. As we ascend in the scale of animal life, we find a nervous system consisting of a few groups of what are called **nerve cells**, and running to these and away from them outgrowths of nerve matter in the shape of fine processes or **fibres**. A nerve cell and its fibres may be said to be the unit of the nervous system in all

animals. In animals, like worms and insects, there are comparatively few of these units; whereas it has been estimated that there are 13,000,000,000 nerve cells and fibres in the nervous system of a normal human being. These nerve cells are very small. They are somewhat

Fig. 39.—Cat's brain, from a photograph, seen from above. 1, 1, the right and left halves of the "forebrain," or cerebrum. A deep fissure separates these two halves. 2, the hind brain, or cerebellum. The fissures and convolutions on this are smaller than on the cerebrum. 3, the medulla oblongata. 4, a part of the spinal cord. A slight fissure may be seen on this, marking the separation of the cord into two halves. The cranial nerves all leave the brain and medulla from the under surface.

rounded bodies, varying in size from $\frac{1}{400}$ to $\frac{1}{3000}$ of an inch in diameter. The fibres which join these cells or extend outwards from them, are of course still smaller in size than the cell bodies.

Broadly speaking, it may be said that the nervous system in man consists of two parts: (*a*) the **cerebro-spinal** portion, and (*b*) the **sympathetic** portion.

The brain, with its 12 pairs of gross nerves, and the spinal cord with 31 pairs of nerves make up what is known as the cerebro-spinal portion. Here the nerve cells are found, covering the surface of the brain more particularly, while the nerve fibres run down through, and form the mass of the central part of the brain.

Fig. 40.—Cat's brain, viewed from the side. A deep transverse fissure separates the cerebrum (1, 1) from the cerebellum (2, 3). The cord (4) is cut off close to the cerebellum. The medulla oblongata lies below the cerebellum, and may be described as the enlarged upper end of the spinal cord. The intelligence of an animal and of different men is believed to vary with the number of the convolutions and the depth of the fissures in the grey matter.

In the spinal cord, on the other hand, the nerve cells occupy the central part or axis, while the fibres run upwards and downwards and surround the central cell matter (see Fig. 44).

The surface of the brain is greyish in color, and is, therefore, called the grey matter. It is marked with rounded convolutions and with fissures varying from one quarter of an inch to one inch deep (see Figs. 39 and 40). Below this grey matter, the brain substance consists of white matter, so called because the fibres are white in color. These fibres are used either in receiving nerve impulses from various parts of the body, or in transmitting impulses from one part of the grey matter to another, or in sending impulses from the brain out to muscles, glands, arteries, etc., in different regions of the body. A diagrammatic view of the cerebro-spinal portion of the nervous system is shown in Fig 41. In the cord, the grey matter, that is, the nerve cells, lie along the central parts—not on its surface as it does in the brain ; and the white matter, that is, the nerve fibres of the cord surround the grey, up and down its length, excepting at the lower end where there is no grey matter, and where the white breaks up into a large number of gross nerves.

The other part of the nervous system lies in the chest and thorax, and has already been referred to as the sympathetic division. It consists of a double chain of nerve cells situated on each side of the vertebral column and extending all the way down from the neck to the upper part of the abdomen. These groups of nerve cells are joined to each other all the way down by nerve fibres. They are joined at intervals to the spinal cord

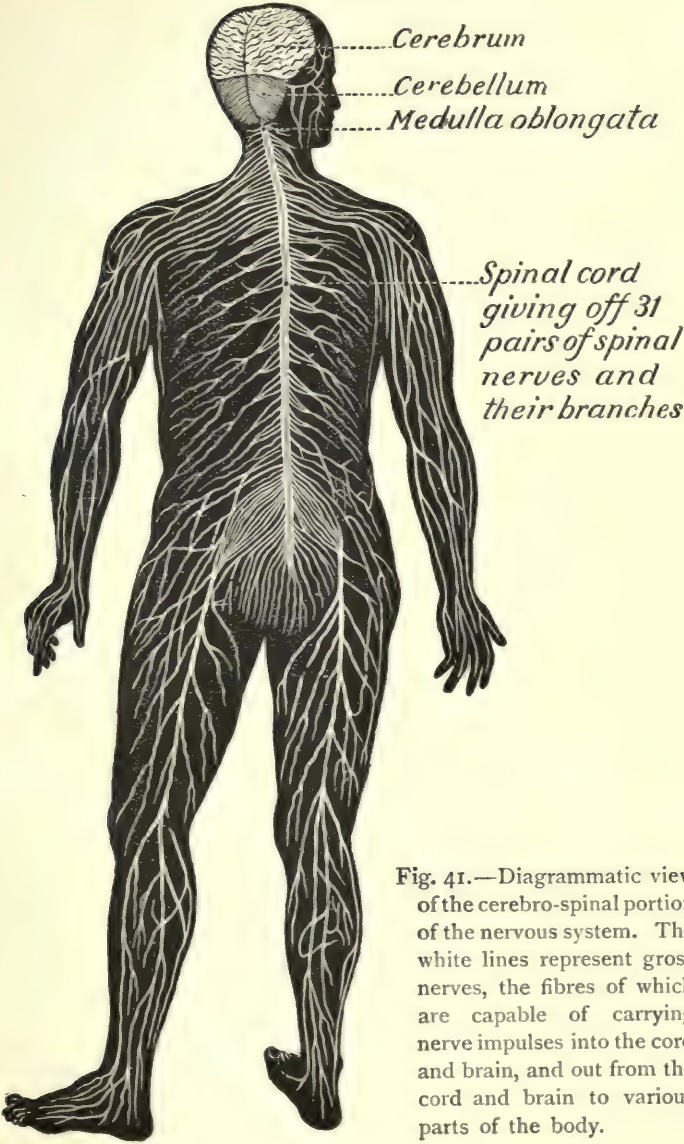

Fig. 41.—Diagrammatic view of the cerebro-spinal portion of the nervous system. The white lines represent gross nerves, the fibres of which are capable of carrying nerve impulses into the cord and brain, and out from the cord and brain to various parts of the body.

behind by nerve fibres, and they send numerous fibres to all of the organs in the chest and abdomen. The sympathetic division is, in fact, an outgrowth from the cerebro-spinal portion. It controls muscular movement of the internal organs, the secretion of the digestive juices, the calibre of the blood-vessels, the quickening of the heart beat, in short, it regulates many operations that are outside of the control of the will.

On the other hand, the cerebro-spinal division controls operations that are partly voluntary and partly involuntary.

LESSON XVIII.

Voluntary Movement.

In the study of voluntary movement we have to do with the cerebro-spinal division of the nervous system, because it is the nerves which are connected with the brain and spinal cord alone that are concerned with voluntary muscular movement of the trunk and limbs.

By a study of certain diseases of the human brain and by experiments upon the brain of some lower animals, physiologists have discovered that certain parts of this organ are connected with the special senses (sight, hearing, taste, touch, smell) on the one hand; and with the voluntary movements of the body on the other hand. In other words, the surface of each half of the brain has been mapped out into areas, some of which are concerned with receiving impulses or messages from various parts of the body, and others of which are concerned with sending out impulses to the voluntary

muscles which control the eyes, head, trunk, or limbs. The remaining areas have not been proved to be connected with any known power of mind, unless it be the area for speech. All these areas are indicated in Fig. 42.

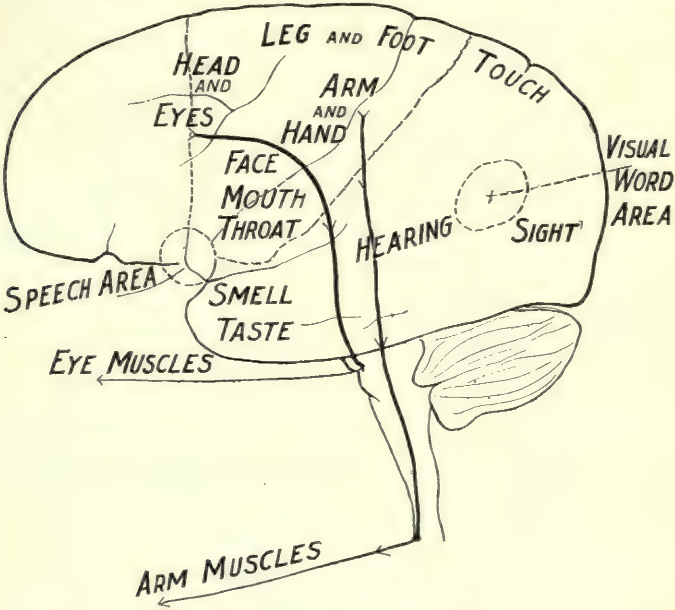

Fig. 42.—Motor and sensory areas of one-half of the brain.

The whole of the grey matter acts as a single organ whose function is what we call intellect or mind. It is concerned in the processes which we call "thought."

The areas which are concerned with movements are, roughly speaking, triangular in shape for each half of the brain. The base of the triangle is the mid-line of the brain, and the other two sides extend downwards to a point about halfway between the ear and the eye.

From the brain cells which compose the grey matter of these areas, nerve fibres extend down through the brain and run out along the gross nerves of the brain or spinal cord, ending finally in the voluntary muscles of the body. All muscles are supplied by nerves which branch and re-branch throughout every part of the muscle.

When we *will* to move any part of the body, for example, the eyes, messages start from the special area in the brain for movements of the eyes, pass downwards and out along three of the cranial nerves, and, on reaching the eye muscles (see Fig. 42), produce contraction of these and consequently movement of the eyes in the direction in which we wish them to move.

Or, to take an example which we have already studied. In the case of the forearm, when we "willed" or commanded the muscle to bend the elbow; the command passed as an impulse from the brain down the upper part of the spinal cord, out along a nerve to the arm. One of the branches of this nerve enters the bicep's muscle. As a result of the nerve message reaching this muscle, it contracts, and the arm is bent (see Fig. 42). The proof of this connection of muscle and nerve was one of the great feats in physiology, and was well known over two hundred years ago. Borelli in the seventeenth century speaks of the experiment as follows:—

"Since all muscles, with some few exceptions, do not manifest vital movement otherwise than in obedience to the will, since the commands of the will are not transmitted from the brain, which is the instrument of the sensitive and the seat of the motive soul, by any other channels than the nerves, as all confess, and as the most decided experiments shew, it is clear that some corporeal

substance must be transmitted along the nerves to the muscles, or else some commotion must be communicated along some substance in the nerves, in such a way, that a very powerful inflation (contraction of the muscle) can be brought about in the twinkling of an eye."

LESSON XIX.

OUTGOING AND INCOMING IMPULSES.

It would appear from the foregoing lesson that there are two different kinds of nerve messages or nerve impulses, as we shall hereafter call them, passing to and fro, all the time throughout an animal's body. One set is passing from the skin and other parts of the body inwards to the spinal cord and brain; and a second set is passing from the brain, spinal cord, or other centres, outwards to muscles, glands or other organs. If we cut the nerve which carries the ingoing or **afferent** impulse,[1] the message never reaches the brain or cord. If we cut the nerve which carries the outgoing or **efferent** impulse,[2]

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[1] Afferent nerve fibres convey impulses to the brain from
- (*a*) Eye.
- (*b*) Ear.
- (*c*) Nose.
- (*d*) Mouth.

and carry impulses to brain, or to the cord or to both, from
- (*a*) Skin.
- (*b*) Muscles.
- (*c*) Chest or abdominal organs.

[2] Efferent nerve fibres convey impulses from the brain, or from the spinal cord or from both, to
- (*a*) Muscles of trunk and limb.
- (*b*) Glands.
- (*c*) Heart.
- (*d*) Blood-vessels.
- (*e*) Internal muscles.

no message reaches the muscle and it does not contract. We can understand how a gross nerve can transmit both ingoing and outgoing impulses, to and from centres in the brain and cord, if we examine any large nerve under a microscope. By its aid we can see that the gross nerve is made up of a large number of very much finer threads lying side by side, and bound together by little bands of connective tissue.

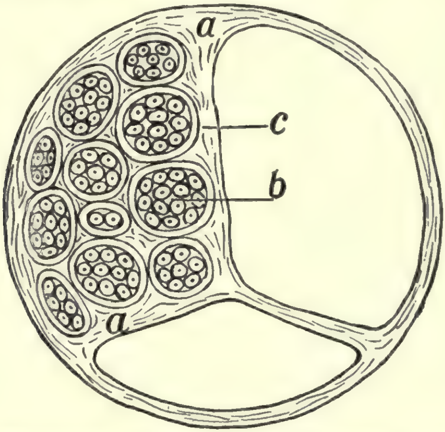

Fig. 43.—Diagrammatic. Cross-section of the sciatic nerve of the leg. *a*, connective tissue subdividing the gross nerve into bundles which supply different parts of the leg. *c*, a smaller bundle of nerve fibres. These smaller bundles are made up of nerve fibres, one of which is marked *b* and represented by a circle with a dot in the centre. This central dot is the essential part of a nerve fibre, and transmits the nerve impulses either inwards or outwards.

These small threads, or nerve fibres, are the paths up and down which nerve impulses travel between the brain and spinal cord on the one hand, and the skin and muscles on the other. It is believed that a nerve fibre

can transmit impulses either inwards or outwards, but never in both directions.

Thus, the white matter of the nervous system in any animal resembles the wires of a telegraph system, and the grey matter, or nerve centres, resemble the principal and the subordinate offices of the company. But there is this difference between the telegraph system and the nervous system : a telegraph wire can transmit a message in either direction, whereas a nerve fibre can transmit a normal impulse in one direction only. The higher centres are all located in the brain ; the lower centres, chiefly in the medulla and the spinal cord.

LESSON XX.

Blocking Nerve Impulses.

If any of the special motor areas become injured or diseased, or if the nerve fibres which extend out to the muscles become injured or diseased, so that the nerve impulses are blocked on their way to the muscles, then by no effort of the will can the voluntary muscles be made to contract. Under these circumstances they are said to be paralyzed.

It sometimes happens that the spinal cord in man gets severed or crushed so badly that all connection with the brain ceases. If this occurs in the middle of the back, the man loses all power over the muscles of his legs, and he loses all sense of feeling in them. The incoming and

outgoing nerve impulses (see Fig. 44) are blocked at the site of the disease or injury. If the soles of his feet are tickled, the legs will be jerked up violently,

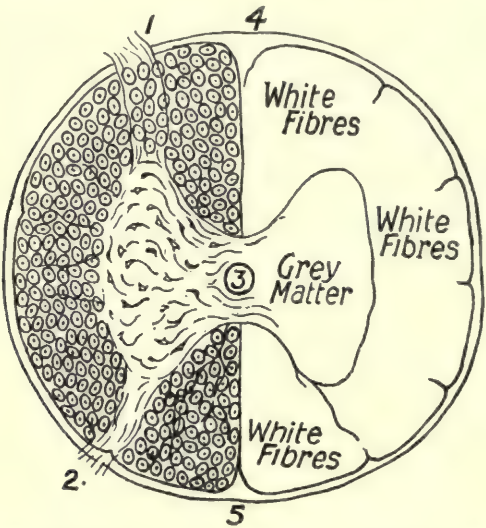

Fig. 44.—Diagrammatic. Cross-section of the spinal cord. Details are indicated on left half only. 1, nerve fibres that convey impulses outwards from the cord; 2, fibres that carry incoming impulses from various parts of the body. The former are efferent, from the grey matter of the brain or spinal cord; the latter are afferent to the grey matter of the cord or brain. 3, the central canal; 4, the anterior fissure; 5, the posterior fissure, separating the cord into two symmetrical halves, just as the brain consists of two symmetrical halves. Each half of the brain and of the cord is connected with corresponding halves of the body.

but the man cannot feel any pain or movement in them, and knows that they are moving only because he sees them.

The relation of muscle and nerve is one of the fundamental facts of animal life. A muscle that is cut off from its nerve supply shrinks up and after some time loses its contractility. The muscles of idiots are seldom if ever symmetrically developed, because the brain is not perfectly developed. They all walk, if they are able to walk at all, with a shuffling gait.

On the other hand, amputation of the leg of an infant is followed by arrested development of certain parts of the brain. The parts affected in this case are the motor areas for the leg and foot. If the eyes are destroyed, another part of the brain fails to develop—the area for vision.

Care of Brain and Body.

1. It would appear from facts like these, that the full and symmetrical development of a child's brain is dependent upon the brain constantly receiving nerve impulses from the developing muscles, and in fact from all parts of the body.

2. If the muscles and special sense organs of a child's body do not get the work or exercise which is necessary for their development, then certain parts of the brain will fail to develop fully.

3. In order, therefore, to have a perfectly formed body and a perfectly developed brain, both body and brain must be exercised and trained together. We cannot have one perfect without the other.

4. The first effect of alcohol upon the nervous system is to produce a temporary exhilaration accompanied by

a more rapid heart beat and waste of the tissues of the body. This is soon followed by relaxation and sluggishness. To get rid of these feelings, a man is tempted to take ever increasing doses of the stimulant, until in course of time the **alcohol habit** is formed. It is this tendency of alcohol to establish a habit that is one of its most dangerous features. As stated previously therefore in these lessons, the only safe rule is to abstain entirely from its use.

LESSON XXI.

Effects of Alcohol and Tobacco.

Senior pupils may be made to understand how strong alcohol can retard digestion if the teacher will take the trouble to perform the following simple experiment.

Place some of the white of an egg in a small tumbler and cover it fully with brandy or whiskey. In the course of fifteen or twenty minutes it will be found that the egg has turned a dead white color, as if it had been boiled hard in water. The alcohol has, in fact, hardened the egg. Now this hardening or coagulation of the egg renders it more difficult to digest, that is, slows the digestive process.

A similar result follows when strong alcohol is added to any kind of broth. In this case the proteid food material is solidified and falls to the bottom of the liquid. This is the invariable effect of alcohol upon all soluble proteid matter, the solidification, as a general rule, having the effect of retarding the process of digestion.

Of course strong alcohol kills and hardens all tissue, and is used extensively in preserving parts of animals for museum specimens. But we cannot truthfully say that the effect of alcohol upon specimens which we wish to preserve from decay is precisely the same as the effect which alcohol has upon the stomach, liver, or other organs in the living human body. No doubt the alcohol when drunk tends to exert its hardening action; but this effect cannot be demonstrated upon the heart, nerves, or intestines of the living human being.

The effects of alcohol upon the heart and circulation of the frog can be demonstrated by any teacher who possesses the requisite knowledge and skill in manipulation; but such experiments are scarcely suitable for young pupils.

Experiments by physiologists, as to the effects of alcohol upon the contractile power of muscles situated in different parts of the body, prove that the muscles of the fingers, for example, when they are made to lift a weight for some time, invariably show diminished working power after alcohol has been taken.

The same holds true in the case of the frog's heart. By the use of apparatus, too elaborate to be described here, the beating of the frog's heart can be recorded upon a sheet of blackened paper. Fig. 45 shows a small

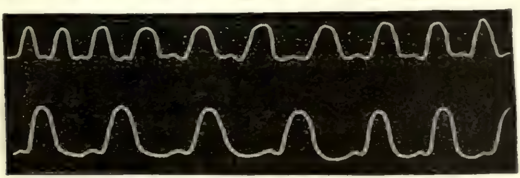

FIG. 45—Tracings showing the beats of a frog's heart. The lower one is the normal; the upper, is the beat after alcohol has been administered for some time.

part of one of these sheets. The lower tracing represents the normal beat, the upper represents the beat in the same animal a short time after it has been given a dose of alcohol. The lower shows six and a half beats; the upper, ten beats in a given length of time. Consequently we infer that alcohol increases the frequency of the heart beat. But another effect must be noted. The height of the lower waves is greater than that of the upper ones. We infer, therefore, that the strength of the heart beat has been lessened as a result of the action of the alcohol upon the heart muscle.

In fact three effects follow the administration of alcohol to a frog: (1) both the force and the frequency of the beats are increased, but only for a short time: (2) later on, the strength of the beat is diminished, but the frequency is maintained, just as shown in the upper tracing: (3) if more alcohol is administered, both the force and frequency are lessened, and finally the heart stops beating altogether.

A much simpler observation, and one which does not require the use of any apparatus, can be made upon any drunken man whom pupils may chance to meet upon the street, namely the flushed appearance of the face. The skin of the face and hands shows this condition most plainly; but the fact is that alcohol sends the blood in large quantities to the blood-vessels of the skin all over the body. This effect is best seen in the young. In the middle-aged and old the skin of the face and hands has grown darker in color, and the flushed condition of the blood capillaries is not so easily recognized; but in young or old the effect is the same.

The blood, being thus largely spread out over the surface of the body, loses its heat by conduction, convection, and radiation, and the temperature of the body is distinctly lowered. This result is particularly marked in the winter, the consequence being that the internal and more vital organs are deprived of their usual amount of heat and rendered more liable to attack from disease-producing bacteria.

A very striking demonstration of the narcotic effect of tobacco may be made by drawing the smoke of a burning cigarette into a bottle, and then placing a living frog in the bottle. A wide-mouthed bottle, holding about a quart, should be selected. This should be fitted with an air-tight cork perforated with two holes into which two glass tubes should be passed, one reaching to the bottom of the bottle, the other just passing through the cork. To the outside end of the tube which reaches the bottom, a rubber tube should be attached so as to form a syphon. The outer end of the other tube should be just large enough to admit one end of a cigarette. The arrangement of apparatus is shown in Fig. 46. Fill the bottle with water. Insert a cigarette in the end of the horizontal tube, light it, and at once start the syphon, so that while the water runs out, the smoke is drawn into the bottle. By compressing the rubber tube with the fingers, the flow of water should be regulated so that the air drawn through the cigarette may cause it to burn brightly. The bottle soon fills with a dense white smoke, part of which, in half an

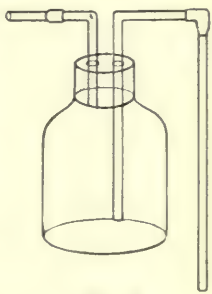

FIG. 46.

hour, settles to the bottom and dissolves in the small quantity of water which the syphon fails to draw out.

If now a living frog be passed into the bottle and the cork replaced as quickly as possible, the animal will become paralyzed in about twenty minutes. On bringing the animal into fresh air it soon recovers.

These effects may be varied a little by using a sharp-pointed syringe, and injecting under the skin of the back of the frog one drop of the yellowish brown liquid which forms at the bottom of the bottle. In this case, paralysis of all the voluntary muscles takes place in a minute or two, the animal being unable to either walk or jump. This effect passes away completely in about half an hour. If three or four drops of this poisonous water be injected, paralysis occurs almost instantaneously. The animal subsequently passes into a narcotic sleep from which it never recovers.

This same water kills vorticellæ and paramœcia immediately. Water fleas die in it within half a minute. The larvæ of the May fly were paralyzed by it in five minutes, and were dead within fifteen minutes. Nematode worms, which are found in decaying matter in pond water, and which were found to live over-night in a five per cent. infusion of cigarette tobacco, lived only half a minute in this solution.

A solution, precisely like the one in this experiment, forms in the mouth and throat in smoking tobacco in the form of a cigarette, cigar or pipe. Some of this poisonous solution is absorbed by the mucous membrane of the mouth, passes into the blood, and is distributed throughout the body producing poisonous and sedative effects upon both young and old.

WHAT EMINENT AUTHORITIES SAY.

An investigation by Baer has shown that the average expectation of life among users and dealers in alcoholic liquors is very much shortened. The following table gives a comparative view of the expectation of life in these who abstained from and those who used alcohol:—

EXPECTATION OF LIFE.

Age.	Abstainers.	Alcohol users.
At 25	30·08 years	26·23 years
35	25·92 "	20·01 "
45	19·92 "	15·19 "
55	14·45 "	11·16 "
65	9·62 "	8·04 "

Table showing the influence of alcohol upon the mortality from various diseases:—

	General Male Population.	Alcohol Venders.
Brain disease	11·77 per cent.	14·43 per cent.
Tuberculosis	30·36 "	36·57 "
Pneumonia and Pleuritis	9·63 "	11·44 "
Heart disease	1·46 "	3·29 "
Kidney disease	1·40 "	2·11 "
Suicide	2·99 "	4·02 "
Old age	22·49 "	7·05 "

"There is no more miserable being than one in whom nothing is habitual but indecision. Could the young but realize how soon they will become mere *walking bundles of habits*, they would give more heed to their conduct while in the plastic state. Every smallest stroke of virtue or vice leaves its never so little scar."—WILLIAM JAMES in *Principles of Psychology*.

"As a surgeon, having vast opportunities of experience in hospital and private practice, I must declare that I always look upon patients who have been in the habit of using spirituous beverages as least

likely to recover from serious maladies, or from shock following operations, and also as those most likely to require longer time for the cure of diseases of a more simple character. I have at times met with cases of fracture of bones occurring in persons of intemperate habits in whom the bones would not unite by bony material, but remained flexible or useless."—J. N. CARNOCHAN, *Professor of Surgery, New York Medical College.*

"All alcohol, is distinctly a poison with certain uses like other poisons, but limitations on its use should be as strict as on arsenic, opium, or strychnine. It is a curiously insidious poison, producing effects which seem to be only relieved by taking more, a remark which applies to another insidious poison, morphia or opium. Alcohol has a certain position in medicine, but in the last twenty-five years its use by the medical profession has steadily and emphatically diminished."—From an address by SIR FREDERICK TREVES, F.R.C.S., *Surgeon to King Edward.*

"Even moderate amounts of tobacco in the form of smoke lower the working power of the human muscle by a high percentage." —W. P. LOMBARD, M.D.

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